

DEPARTMENT OF THE ARMY

CORPS OF ENGINEERS

BEACH EROSION BOARD
OFFICE OF THE CHIEF OF ENGINEERS

DURABILITY OF STEEL SHEET PILING IN SHORE STRUCTURES

TECHNICAL MEMORANDUM NO. 12

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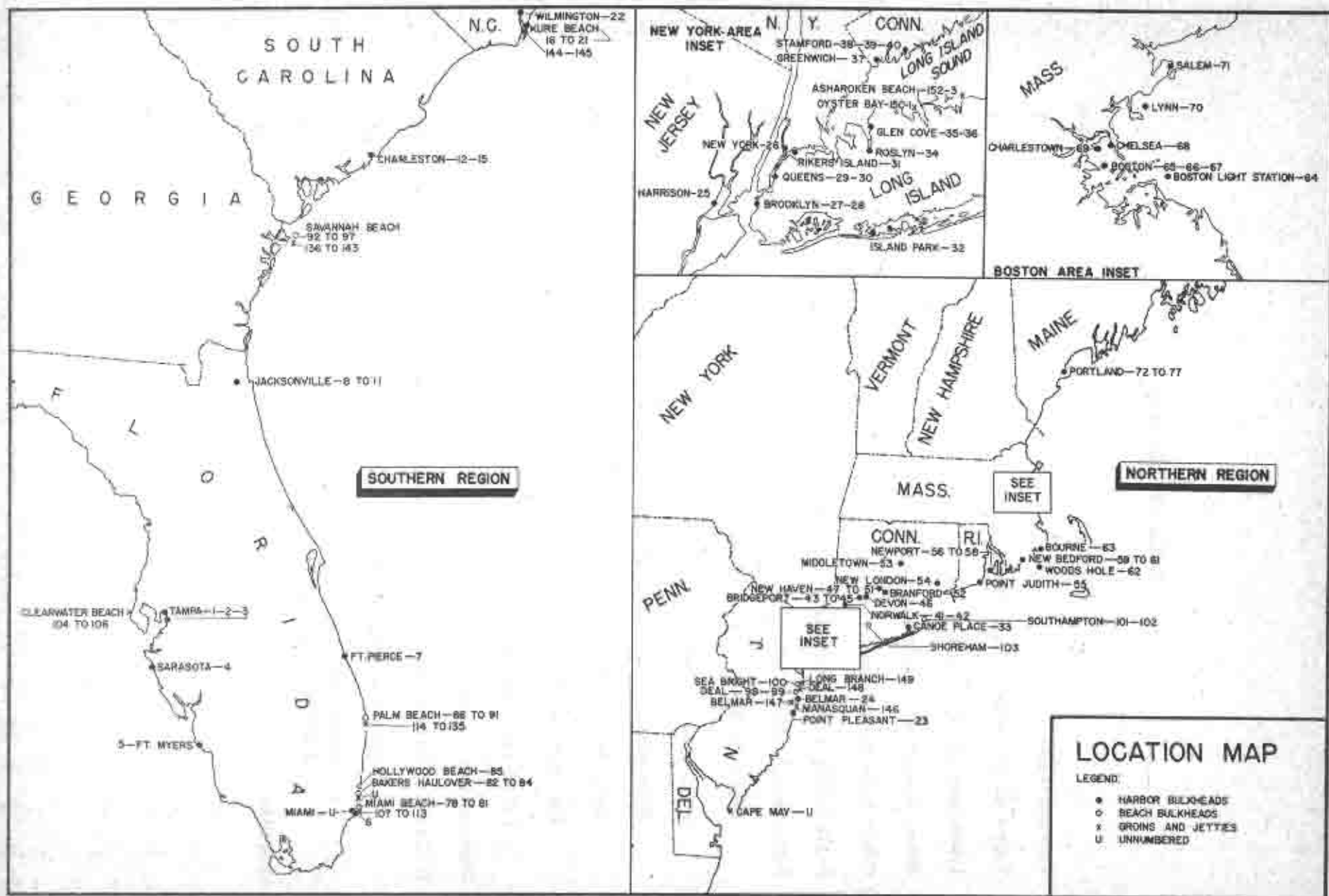
FOREWORD

This report was prepared by Albert C. Rayner, Chief, Reports and Publications Division and Culbertson W. Ross, Engineer, Research Division, Beach Erosion Board.

The study was a cooperative effort of the Beach Erosion Board and a number of District Offices of the Corps of Engineers along the Atlantic Coast. The plan of operations was developed by and the first inspection was made under the supervision of Mr. Ralph F. Rhodes, Engineer, Savannah District. Subsequent inspections were under the supervision of Mr. Jay V. Hall, Jr., Engineer, Beach Erosion Board. Acknowledgment is made to the many owners of structures who contributed to the study by permitting drilling and measurement of piling.

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DURABILITY OF STEEL SHEET PILING IN SHORE STRUCTURES

INTRODUCTION

1. As a basis for more accurate estimates of the useful life of steel sheet piling, the Beach Erosion Board, in cooperation with a number of District offices of the Corps of Engineers, made a survey of the rate of deterioration of steel sheet piling. Ninety-four structures located along the Atlantic Coast of the United States and the Gulf Coast of Florida were examined. The structures were selected for various conditions of exposure and treatment. Most were exposed to normal sea water or sea water only moderately diluted with fresh water. A few were exposed to fresh water with only occasional intrusions of sea water.

2. Measurements were made of the thickness of the webs of 153 groups of piles. In most cases, each group comprised 5 piles having similar environment and three sets of measurements were made covering the period of approximately 10 years from 1936 to 1946. Where practicable, measurements were taken at several elevations on each pile to include both tidal and atmospheric exposures. The removal of piling from structures at two locations permitted measurement of the entire length of each pile to obtain data on rates of loss under water and in earth.

TYPES OF STRUCTURES INVESTIGATED

3. The piling groups studied are classified by type of structure as harbor bulkheads, beach bulkheads, and groins. Harbor bulkheads are found in wharves, piers, slips and retaining walls, all of which are protected to some extent from wave action. Backfill generally protects one surface of the piling, but the top portion of the piles may be exposed to the atmosphere on both sides. The portion between the levels of high and low water is exposed to alternate wetting or drying. The third portion is always under water, and the lowest portion is buried in the harbor bottom. Beach bulkheads are located along the shore to protect the land from storm waves. Those located back of the high water line are not subject to frequent wetting, except by salt spray from waves. The backfill and the beach material are usually sand, but occasionally consist of coarser materials. Groins are structures built along the beach generally normal to the shore line to retard littoral currents near the shore with a view to accumulating or retaining beach material in a specific area. Some part of the groin surface is normally subject to rapid movement of beach material caused primarily by wave action. The exposure of jetties is generally similar to that of groins. Several pile groups in jetties have been classified with and analyzed with those in groins.

LOCATIONS OF STRUCTURES

4. In order to have distinct differences in climatic conditions, structures were selected by regions northward from Point Pleasant, New Jersey, and southward from Wilmington, North Carolina. A number of groins

located at Cape May and Cape May Point, New Jersey, were also observed during the investigation, but were not measured. No suitable beach bulkheads or groins were found north of Long Island, New York.

5. The various locations at which steel sheet piling was measured or observed are shown on Figure 1 (frontispiece). The locations of the individual structures and piling groups, as well as exposure characteristics and other pertinent details, are given in Appendix A.

MEASUREMENTS OF THICKNESS OF PILING

6. The thickness of the web of each pile was determined by 8 or 10 measurements at each inspection. Rust, paint, and scale were carefully cleaned from both surfaces of the web before the measurements were made. Where practicable, 10 measurements were made near the top of the pile by means of a large (striding) micrometer. Where it was impossible to use the striding micrometer, a 3/4-inch hole was drilled through the web and 8 equally spaced measurements were made around this hole with a small micrometer caliper (hub micrometer). Where there was backfill which could not be excavated, a small amount of the backfill material was removed through the hole, paper was forced into the cavity to form a lining and the inner surface of the steel was cleaned with special scrapers operated through the hole.

7. Where practicable, measurements were made of the thickness of sound metal in the web of each pile at four zones defined relative to tidal planes, namely approximately at mean low water, mean tide level, mean high water and above high tide. After the measurements were completed, the holes were filled with soft iron or lead plugs. New holes several inches from the old holes were drilled for the measurements at subsequent inspections. Averages of measured thicknesses by groups for each inspection are given in Table 1, classified by zones relative to tidal planes. The tabulated values are usually averages of at least 40 measurements, as in general each group comprised 5 piles and 8 or 10 measurements were made of each pile in each zone. Data for piles which were pulled and measured throughout their lengths are given in Table 2.

OTHER DATA ASSEMBLED

8. Data relating to geographical locations, date of installation, condition of piling when installed (new or used) and nominal thickness of piling are given in Table 1. Data are presented classified by type of structure.

9. Other data recorded when practicable in connection with the investigation are as follows:

- | | |
|---|--|
| a. Manufacturer | i. Tidal range |
| b. Section of piling | j. Nature of adjacent materials |
| c. Copper content, if any | k. Type of capping, if any |
| d. Distance from nearest breakers | l. Condition of paint at each inspection |
| e. Exposure to direct wave action | m. Amount of rusting & pitting |
| f. Estimated intensity of currents | n. Oil or grease scum |
| g. Salinity (estimated average condition) | o. Marine life |
| h. Pollution | |

As none of the foregoing factors appeared to be of major importance in determining the durability of steel piling, the detailed data on these factors are not tabulated. However, much of the data obtained are included in Appendix A. Data on beach materials, obtained for some beach bulkheads and groins, are also included in Appendix A.

RELIABILITY OF MEASUREMENTS AND COMPUTED RATES OF LOSS

10. The web thickness of the piles was measured with micrometers reading to 0.001 inch. The micrometers were checked and adjusted frequently. Although the measurements were at times made under difficult conditions, the number of measurements is considered adequate to render the effects of random errors and pitting unimportant.

11. As the measurements were made by a number of inspectors, it is possible that the surfaces were not always cleaned to the same degree. However, it is unlikely that errors from this source are serious, as this type of error is compensating.

12. Since the second and third sets of measurements were made at holes drilled several inches from the old ones, an error was introduced in the computed rate of loss of steel in cases where the original web thickness was not uniform. The webs of most new piles are of nearly uniform thickness, but in certain types the thickness of the webs increases markedly from the center towards the edge. In known cases of these latter types, the new holes were drilled either vertically above or below the old holes. However, there are certain groups in which the change in thickness was less noticeable and in a few cases an increase in measured thickness resulted, presumably because of the change in the location of the holes.

13. The nominal thickness, as well as the measurements of the webs, was generally used in computing changes in thickness. Variations in thickness of new piling result from wear or lack of adjustment of the rollers. A weight tolerance of $2\frac{1}{2}$ per cent either way from listed weights is standard permissible mill variation. The first measurements were frequently greater than the nominal thickness by more than $2\frac{1}{2}$ per cent, indicating that the mills tended to produce piles which were overthick. When the web thickness determined from the first measurements exceeded the nominal thickness, the former has been taken as the initial thickness in computing losses.

14. The effect of errors in the determination of the thickness on the annual rate of loss decreases with time. The error of the rate of loss, as given in Table 1, is probably seldom larger than 0.002 inch per year.

15. The computed losses of thickness are losses from all causes. The two causes which are believed to be principally responsible are: (a) corrosion, defined herein as loss due to chemical reaction with the environment, and (b) abrasion, loss due to wearing away by friction of moving materials. The latter appears to be an important factor in the case of groins, although the removal of rust and exposure of bare steel by abrasion may accelerate the corrosive process.

PRINCIPAL FACTORS AFFECTING THE RATE OF DETERIORATION

16. All data assembled in connection with the investigation, as listed in a previous paragraph, have been considered to determine their significance relative to the rate of deterioration of piling. The number of variables considered which may have an effect on the rate of loss of steel is so large that even the number of measurements made in this survey is inadequate to cover all conditions thoroughly. Data secured appeared adequate to warrant general conclusions by comparison of rates only under the following categories:

- a. Type of structure
- b. Geographical location
- c. Zone relative to tidal planes
- d. Sand, earth or other cover
- e. Exposure to salt spray
- f. Paint protection.

Table 3 contains data on rates of loss for various conditions under these categories. The summary at the end of the table enables comparison of rates of loss in the several categories.

17. Type of Structure. The average rates of loss of thickness by types of structure were as follows:

Harbor bulkheads (all measurements)	0.0033 inch per year
Beach bulkheads (" ")	0.016 " " "
Groins and jetties " ")	0.016 " " "

Comparison of these rates indicates a durability of steel sheet piling in harbor bulkheads about 5 times that in other shore structures.

18. Observation of perforation of groins at Cape May and Cape May Point, New Jersey, provides additional data on rates of loss. All of these groins were built of piling having nominal web and flange thicknesses of 0.281 and 0.250 inch respectively. Some holes were observed after 4 years, indicating a maximum annual rate of loss of about 0.06 or 0.07 inch. The average time in which holes first appeared was about 7 years,

indicating a rate of loss of about 0.04 inch per year. As may be expected, the rates indicated by these observations are larger than average rates derived from measured holes, since the perforations naturally occur at points of worst exposure. However, natural holes observed in measured piling (Table 1) provide examples of similar rates of loss. A more detailed study of deterioration of steel piling in groins is contained in a previous publication (1).

19. Geographical Location. The average rates of loss of thickness for northern and southern regions for the three types of structures were as follows:

<u>Region</u>	<u>Harbor Bulkheads Inch/year</u>	<u>Beach Bulkheads Inch/year</u>	<u>Groins and Jetties Inch/year</u>
Southern	0.0062	0.017	0.018
Northern	0.0023	0.0075	0.011

Comparison of these rates indicates a durability of steel piling in the Northern Region averaging about double that in the Southern Region. However, the number of measurements of groin piling in the Northern Region was relatively small. Observations of natural perforations in unmeasured piles in New Jersey indicate high rates of loss, similar to those experienced in the South. A general conclusion that steel piling in groins has materially greater durability in the North than in the South appears to be unwarranted.

20. Zone Relative to Tidal Planes. The average rates of loss of thickness for the several zones relative to tidal planes were as follows:

<u>Zone</u>	<u>Harbor Bulkheads Inch/year</u>	<u>Beach Bulkheads Inch/year</u>	<u>Groins and Jetties Inch/year</u>
8' above MHW	} 0.0049	0.020	} 0.010
5' to 8' above MHW		0.022	
2' to 5' above MHW		0.0081	
Mean high water	0.0027	0.0074	0.0055
Mean tide level	0.0024	0.001	0.024
Mean low water	0.0035	0.002	0.028

Comparison of rates for harbor bulkheads indicates little difference in the tidal zone from mean low water to mean high water. Above mean high water a rate about 70 per cent greater than the average rate in the tidal zone is indicated. For beach bulkheads, the rates for the area more than 5 feet above mean high water were somewhat more than double the rates

(1) Beach Erosion Board, Technical Memorandum No. 10, "Experimental Steel Sheet Pile Groins, Palm Beach, Florida"

For the area between mean high water and 5 feet above mean high water. Piling at only two locations was measured below mean high water. In each case sand covered the zone at least part of the time and the rates of loss were negligible. For groins and jetties, rates for areas at and above mean high water averaged about one-third of the rates for the areas exposed to tidal and wave action.

21. Measurements of pulled steel piling given in Table 2 provide data on deterioration by zones below mean low water. From mean low water to the ground line, the zone continuously submerged, the rate of loss averaged 0.0035 inch per year, the highest rates being within a few feet below the mean low water line. In the Miami groups lesser peaks in the rate also appeared just above the ground line. Below the ground line the average rate of loss was slightly under 0.002 inch per year.

21. Measurements of pulled steel piling given in Table 2 provide data on deterioration by zones below mean low water. From mean low water to the ground line, the zone continuously submerged, the rate of loss averaged 0.0035 inch per year, the highest rates being within a few feet below the mean low water line. In the Miami groups lesser peaks in the rate also appeared just above the ground line. Below the ground line the average rate of loss was slightly under 0.002 inch per year.

22. Sand, Earth or Other Cover. The average rates of loss of thickness for several conditions of cover were as follows:

<u>Cover</u>	<u>Harbor Bulkheads Inch/year</u>	<u>Beach Bulkheads Inch/year</u>	<u>Groins and Jetties Inch/year</u>
No cover on either surface of pile (NN)	0.0075	0.027	0.019
One surface never covered, other covered part time (NP)	0.0076	0.020	0.014
One surface only covered (NC)	0.0026	0.0094	0.020
One surface always covered, other covered part time (PC)		0.0065	0.0057
Both surfaces covered part time (PP)			0.017
Both surfaces always covered (CC)		0.0017	0.0026

Comparison of rates for harbor bulkheads indicates that lack of backfill for all or part of the time greatly increases the rate of loss. For beach bulkheads the rate of loss rapidly decreased as the cover increased. For groins and jetties the rates of loss were uniformly high except for those covered on both sides all or part of the time.

23. Exposure to salt spray. The average rates of loss of thickness for several conditions of exposure to salt spray follow. All beach bulkheads, groins and jetties are considered to be subject to heavy spray.

<u>Spray Condition</u>	<u>Harbor Bulkhead Inch/year</u>	<u>Beach Bulkhead Inch/year</u>	<u>Groins and Jetties Inch/year</u>
Heavy	0.0083	0.016	0.016
Moderate	0.0041		
Light or none	0.0024		

Comparison indicates much higher rates of loss where piling is subject to salt spray.

24. Paint Protection. The average rates of loss of thickness without painting and with painting on one or more occasions were as follows:

<u>Painting</u>	<u>Harbor Bulkheads Inch/year</u>	<u>Beach Bulkheads Inch/year</u>	<u>Groins and Jetties Inch/year</u>
None	0.0045	0.018	0.020
At least once	0.0027	0.011	0.010

Comparison indicates a substantially lower rate of loss for structures that had been painted at least once. Data on composition of paints and the manner of application are too limited to permit study of these factors. Few of the structures studied were painted regularly. The fact that occasional painting reduced the rate of loss substantially indicates that regular painting would result in greater reduction. Determination of the economic justification of regular painting would require study of painting costs. As rates of loss for beach bulkheads are high and as painting of these structures is less costly than complete painting of harbor bulkheads, regular painting of beach bulkheads may be justified. The same is true of the zone above mean high water of harbor bulkheads. Painting of groins and jetties in the tidal zone, subject to abrasive action, probably could not be justified.

CONCLUSIONS

25. The mean rate of loss of thickness of steel sheet piling based on a total of 451 weighted averages was about 0.008 inch per year. The rates of loss vary materially under different environmental conditions. Consequently, different types of structure and the several portions of the same structure have different rates of loss. In addition to specific rates of loss under various conditions, presented in previous paragraphs, the data are adequate to warrant the following general conclusions:

a. The rates of loss are much lower for harbor bulkheads than for other shore structures studied;

b. The rates of loss are lower in the eastern and northeastern United States for harbor and beach bulkheads than in southeastern United States;

c. The rates of loss for beach and harbor bulkheads are materially higher for surfaces above mean high water than for surfaces within the tidal range. The rates of loss for groins and jetties are much greater at mean tide and mean low water levels than at higher elevations.

d. Sand or earth cover materially decreases the rate of loss, the rates of loss for all practical purposes being negligible for piling always covered on both sides;

e. Exposure to salt spray greatly increases the rate of loss;

f. Painting, either initially or at irregular intervals, materially reduces the rate of loss.

26. The useful life of steel sheet pile structures depends on the original thickness of the steel, the rate of loss of thickness, and the thickness of the piling when the structure is no longer useful because of loss of thickness. The data presented in the tables will enable the designer to estimate the probable life of a structure, giving due consideration to environmental factors, and to determine the justification of protective coverings such as paint, concrete or wood sheathing to reduce the rate of loss in the more vulnerable portions of the structure.

TABLE 1
DISTORTION OF STEEL GUNST PLATE

TABLE 1 (cont'd)

Group Number	Location	Year Installed & Condition	Rope (1)	Nominal Thickness Inch	Average Measured Thickness Inch			Weighted Average Loss of Thickness Inch/Yr. (2)
					1st	2nd	3rd	
Part I - Harbor Bulkheads								
1	Tampa, Fla.	1927 New	above SW MEL above SW	0.406 0.402 0.344	0.360 0.432 hole in flange	0.354 0.396 2nd insp., 0.028	0.212 0.370 0.000	0.011 0.002 0.028
2	Tampa, Fla.	1930 New	above SW MEL above SW	0.609 0.591 0.375	0.554 0.573 hole in flange	0.411 0.494 0.000	0.272 0.404 0.000	0.002 0.008 0.001
3	Tampa, Fla.	1933 New	above SW MEL	0.609 0.592	0.579 0.388	0.511 0.563	0.450 0.000	0.008 0.000
4	Sarasota, Fla.	1926 New	above SW MEL above SW	0.375 0.333 0.339	0.299 0.313 hole	0.212 0.258 (1st inspection)	0.018 0.006 0.036	0.018 0.006 0.036
5	Fort Myers, Fla.	1929 New	above SW MEL MEL	0.313 0.295 0.272	0.245 0.275 0.255	0.199 0.258 0.000	0.125 0.004 0.005	0.022 0.004 0.005
6	Wesl Beach, Fla.	1930 New	above SW MEL	0.375 0.395	0.348 0.305	0.302 0.379	0.279 0.000	0.011 0.001
7	Fort Pierce, Fla.	1929 New	above SW MEL above SW	0.313 0.241 hole	0.200 0.217 0.000	0.116 0.218 0.000	0.023 0.004 0.008	0.013 0.004 0.008
8	Jacksonville, Fla.	1913 New	above SW MEL above SW	0.375 0.276 0.353	0.276 0.353 hole	0.006 0.001 (1st inspection)	0.006 0.001 0.017	0.006 0.001 0.017
9	Jacksonville, Fla.	1929 New	above SW MEL	0.313 0.310	0.310 0.295	0.316 0.299	0.316 0.000	0.000 0.001
10	Jacksonville, Fla.	1929 New	above SW MEL	0.313 0.310	0.313 0.313	0.316 0.316	0.000 0.000	0.000 0.000
11	Jacksonville, Fla.	1916 New	above SW MEL MEL	0.375 0.385 0.378	0.376 0.379 0.408	0.373 0.363 0.370	0.001 0.001 0.008	0.001 0.001 0.008
12	Charleston, S.C.	1930 New	above SW MEL MEL MEL	0.609 0.593 0.597 0.375	0.599 0.577 0.595 0.514	0.596 0.555 0.599 0.485	0.001 0.004 0.001 0.009	0.001 0.004 0.001 0.009
13	Charleston, S.C.	1930 New	above SW MEL MEL MEL	0.609 0.583 0.590 0.570	0.596 0.568 0.587 0.514	0.593 0.554 0.608 0.472	0.001 0.000 0.000 0.009	0.001 0.000 0.000 0.009

Group Number	Location	Year Installed & Condition	Rope (1)	Nominal Thickness Inch	Average Measured Thickness Inch			Weighted Average Loss of Thickness Inch/yr. (2)
					1st	2nd	3rd	
14	Charleston, S. C.	1930 New	above SW MEL MEL MEL	0.609 0.608 0.603 0.588	0.608 0.582 0.602 0.541	0.604 0.589 0.594 0.516	0.006 0.001 0.001 0.007	
15	Charleston, S. C.	1935 New	above SW MEL MEL	0.375 0.214 0.258	0.199 0.189 0.256	0.065 0.113 0.240	0.000 0.011 0.002	
16	Kure Beach, S. C.	1933 New	above SW MEL MEL MEL	0.375 0.381 0.382 0.385	0.338 0.370 0.378 0.375	0.297 0.344 0.375 0.360	0.006 0.003 0.000 0.001	
17	Kure Beach, S. C.	1933 New	above SW MEL MEL MEL	0.375 0.365 0.376 0.367	0.304 0.348 0.368 0.319	0.297 0.344 0.375 0.360	0.006 0.003 0.000 0.001	
18	Kure Beach, S. C.	1933 New	above SW MEL MEL MEL	0.375 0.348 0.371 0.377	0.213 0.348 0.368 0.318	0.065 0.113 0.240 0.360	0.000 0.011 0.002 0.007	
19	Kure Beach, S. C.	1933 New	above SW MEL	0.375 0.355	0.338 0.372	0.297 0.344	0.006 0.003	
20	Kure Beach, S. C.	1933 New	above SW MEL MEL MEL	0.375 0.372 0.351 0.372	0.346 0.326 0.308 0.365	0.347 0.298 0.381 0.355	0.003 0.006 0.001 0.008	
21	Gape Fear River, S.C.	1937 New	above SW MEL MEL	0.375 0.403 0.400	0.384 0.392 0.393	0.317 0.389 0.393	0.006 0.001 0.001	
22	Wilmington, S. C.	1929 New	above SW MEL MEL MEL	0.375 0.395 0.375 0.383	0.385 0.377 0.381 0.385	0.380 0.368 0.381 0.377	0.000 0.001 0.000 0.003	
23	Point Pleasant, N.J.	1931 New	above SW MEL MEL	0.375 0.266 0.251	0.296 0.291 0.271	0.275 0.294 0.294	0.008 0.004 0.001	
24	Wilmington, N. C.	1931 New	above SW MEL MEL MEL	0.375 0.363 0.358 0.369	0.296 0.335 0.347 0.332	0.275 0.304 0.346 0.348	0.008 0.004 0.002 0.003	
25	Harrison, N. J.	1929 New	above SW MEL MEL MEL	0.609 0.602 0.604 0.377	0.380 0.397 0.383 0.378	0.391 0.396 0.389 0.373	0.001 0.001 0.001 0.002	
26	Wilmington, N. C.	1928 New	above SW MEL MEL MEL	0.609 0.413 0.408 0.375	0.375 0.398 0.370 0.334	0.347 0.383 0.370 0.384	0.004 0.009 0.003 0.005	
27	Brooklyn, N. Y.	1932 New	above SW MEL MEL MEL	0.390 0.389 0.377 0.382	0.398 0.368 0.367 0.371	0.370 0.367 0.363 0.365	0.001 0.002 0.002 0.002	
28	Brooklyn, N. Y.	1930 New	above SW MEL MEL	0.608 0.394 0.392	0.346 0.365 0.369	0.375 0.355 0.355	0.004 0.003 0.004	
29	Queens, N. Y.	1928 New	above SW MEL MEL MEL	0.609 0.592 0.583 0.568	0.581 0.588 0.557 0.536	0.569 0.582 0.546 0.523	0.002 0.003 0.002 0.002	

(1) Above SW indicates more than 2 feet above SW
MEL indicates between 3/4 tide and 6 feet above SW
MEL indicates between 1/4 tide and 3/4 tide
MEL indicates below 1/4 tide

(2) Losses between installation and 1st inspection and between 1st and 2nd inspections were given a weight of 1, between installation and 2nd inspection and between 2nd and 3rd inspections a weight of 2, between installation and 3rd inspection and between 1st and 2nd inspections a weight of 3. The 1st inspection was made from 1936 to 1938, the 2nd in 1940-41 and the 3rd in 1948.

TABLE 1 (Cont'd.)

Group Number	Location	Year Installed & Condition	Core (1)	Vertical Thickness Inch	Average Measured Thickness Inch	Weighted Average Loss of Thickness Inch/Yr. (2)
30	Queens, N. Y.	1932 New	above HW MHW MTL MLW	0.400	0.400 0.389 0.373 0.406 0.382 0.371 0.397 0.370 0.357 0.383 0.358 0.348	0.002 0.003 0.004 0.004
31	Pikare Island, N.Y.	1930 New	above HW MHW MTL MLW	0.516	0.495 0.448 0.423 0.461 0.434 0.420 0.477 0.450 0.442 0.484 0.461 0.453	0.006 0.006 0.005 0.004
32	Inland Park, L.I., N. Y.	1929 New	MHW MHW MTL MLW	0.406	0.370 0.348 0.349 0.405 0.399 0.377 0.410 0.408 0.390 0.408 0.396 0.392	0.003 0.002 0.001 0.001
33	Cause Place, L.I., N. Y.	1931 New	above HW MHW	0.375	0.394 0.388 0.377 0.395 0.383 0.371	0.004 0.002
34	Wardstead Harbor, Babylon, L.I., N.Y.	1926 New	above HW MHW MTL MLW	0.375	0.339 0.293 0.287 0.345 0.310 0.296 0.312 0.298 0.281 0.354 0.321 0.312	0.002 0.002 0.004 0.003
35	High Cove, L.I., N. Y.	1938 New	above HW MHW MTL MLW	0.375	0.375 0.362 0.355 0.379 0.368 0.364 0.360 0.347 0.341 0.364 0.350 0.344	0.001 0.001 0.002 0.002
36	High Cove, L.I., N. Y.	1938 New	MHW MTL MLW	0.375	0.370 0.362 0.368 0.362 0.364 0.350 0.361 0.339 0.332	0.001 0.002 0.002
37	Stamford, Conn.	1924 New	above HW MHW MTL MLW	0.375	0.379 0.374 0.369 0.345 0.339 0.342 0.335 0.321 0.326 0.338 0.317 0.297	0.003 0.001 0.006 0.004
38	Stamford, Conn.	1929 New	above HW MHW MTL MLW	0.406	0.407 0.411 0.415 0.406 0.407 0.410 0.393 0.396 0.389 0.360 0.380 0.368	0.000 0.000 0.002 0.002
39	Stamford, Conn.	1934 New	above HW MHW MTL MLW	0.375	0.387 0.383 0.376 0.399 0.399 0.368 0.370 0.347 0.298 0.399 0.372 0.337	0.001 0.001 0.008 0.004
40	Stamford, Conn.	1923 New	above HW MHW MTL MLW	0.353	0.435 0.406 0.432 0.415 0.349 0.303 0.366 0.383	0.009 0.003 0.008 0.005
41	Stamford, Conn.	1931 New	above HW MHW MTL MLW	0.362	0.360 0.356 0.335 0.358 0.354 0.327 0.350 0.346 0.315 0.355 0.344 0.331	0.002 0.003 0.003 0.002
42	Stamford, Conn.	1929 New	MHW MHW MTL MTL	0.313	0.288 0.263 0.269 0.293 0.293 0.283 0.312 0.309 0.319 0.319 0.309 0.309	0.002 0.003 0.002 0.002
43	Stamford, Conn.	1932 New	MHW MHW MTL MLW	0.406	0.407 0.406 0.410 0.406 0.398 0.420 0.398 0.400 0.395 0.404 0.402 0.394	0.000 0.000 0.001 0.001
44	Bridgeport, Conn.	1932 New	above HW MHW MTL MLW	0.406	0.418 0.393 0.399 0.412 0.407 0.420 0.396 0.388 0.366 0.403 0.409 0.407	0.001 0.000 0.003 0.001

TABLE 1 (Cont'd.)

Group Number	Location	Year Installed & Condition	Core (1)	Vertical Thickness Inch	Average Measured Thickness Inch	Weighted Average Loss of Thickness Inch/Yr. (2)
45	Bridgeport, Conn.	1931 New	MHW MTL MLW	0.375	0.381 0.398 0.373 0.470 0.354 0.233 0.309 0.288 0.269	0.005 0.005 0.004
46	Bridgeport, Conn.	1928 New	above HW MHW MTL MLW	0.406	0.397 0.397 0.402 0.398 0.397 0.396 0.395 0.379 0.380 0.394 0.387 0.377	0.000 0.000 0.001 0.001
47	New Haven, Conn.	1927 New	above HW MHW MHW MTL	0.406	0.408 0.409 0.403 0.412 0.417 0.404 0.395 0.377 0.401 0.397 0.383 0.377	0.001 0.000 0.000 0.002
48	New Haven, Conn.	1927 New	above HW MHW MHW MTL	0.406	0.408 0.408 0.402 0.404 0.410 0.405 0.387 0.387 0.379 0.401 0.402 0.385	0.000 0.000 0.001 0.002
49	New Haven, Conn.	1928 New	above HW MHW MTL MTL	0.409	0.406 0.407 0.415 0.402 0.402 0.400 0.384 0.379 0.334 0.384 0.376 0.348	0.000 0.000 0.003 0.004
50	New Haven, Conn.	1930 New	MHW MHW MTL MLW	0.375	0.371 0.370 0.382 0.365 0.360 0.363 0.359 0.364 0.316 0.370 0.365 0.358	0.000 0.002 0.003 0.002
51	New Haven, Conn.	1931 New	above HW MHW MTL	0.375	0.385 0.386 0.387 0.386 0.385 0.376 0.364 0.349 0.319	0.000 0.001 0.003
52	Stamford, Conn.	1924 New	above HW MHW MTL MLW	0.375	0.371 0.377 0.371 0.378 0.373 0.367 0.360 0.363 0.363 0.354 0.364 0.360	0.000 0.000 0.001 0.001
53	Stamford, Conn.	1929 New	above HW MHW	0.375	0.378 0.365 0.368 0.369 0.366 0.371	0.000 0.000
54	New London, Conn.	1936 New	above HW MHW MTL MLW	0.406	0.387 0.391 0.396 0.386 0.388 0.399 0.389 0.389 0.355 0.389 0.381 0.380	0.000 0.001 0.003 0.002
55	Point Judith, R. I.	1931 New	above HW MHW MTL MTL	0.375	0.401 0.411 0.399 0.400 0.368 0.351 0.397 0.403 0.402 0.398 0.405 0.386	0.000 0.005 0.000 0.001
56	Newport, R. I.	1934 New	above HW MHW MHW MTL	0.375	0.401 0.394 0.399 0.404 0.392 0.382 0.402 0.385 0.363 0.405 0.384 0.378	0.001 0.002 0.004 0.003
57	Newport, R. I.	1934 New	MHW MHW MTL MLW	0.375	0.403 0.394 0.399 0.399 0.374 0.376 0.394 0.373 0.377 0.395 0.367 0.357	0.001 0.002 0.002 0.002
58	Newport, R. I.	1932 New	above HW MHW MTL MLW	0.406	0.409 0.403 0.406 0.405 0.405 0.404 0.403 0.400 0.400 0.405 0.402 0.402	0.000 0.000 0.000 0.000

TABLE 1 (cont'd)

Group Number	Location	Year Installed & Condition	Form (1)	Minimal Thickness Inch	Average Measured Thickness Inch	Weighted Average Loss of Thickness Inch/yr. (2)
59	New Bedford, Mass.	1931 New	above HW MTL MTR	0.375	0.391 0.393 0.391 0.383 0.379 0.378 0.370 0.358 0.345	0.000 0.001 0.003
60	New Bedford, Mass.	1935 New	above HW MTL MTR	0.375	0.388 0.387 0.382 0.380 0.384 0.365 0.379 0.372 0.367 0.376 0.383 0.349	0.005 0.002 0.004 0.003
61	New Bedford, Mass.	1931 New	MTL	0.375	0.359 0.366 0.368	0.003
62	Woods Hole, Mass.	1931 New	above HW MTL MTR	0.375	0.379 0.374 0.360 0.369 0.373 0.352 0.369 0.364 0.360	0.004 0.003 0.002
63	Scituate, Mass.	1932 New	above HW MTL MTR	0.484	0.493 0.489 0.489 0.484 0.488 0.491 0.491 0.491 0.487 0.476 0.489 0.484	0.000 0.000 0.000 0.000
64	Scituate, Mass.	1932 New	above HW MTL MTR	0.484	0.410 0.406 0.372 0.391 0.376 0.318 0.382 0.367 0.341 0.406 0.396 0.366	0.007 0.010 0.009 0.005
65	Scituate, Mass.	1932 New	MTL MTR	0.484	0.480 0.479 0.475 0.485 0.480 0.483 0.487 0.484 0.485 0.489 0.478 0.337	0.001 0.000 0.000 0.013
66	Scituate, Mass.	1935 New	MTL MTR	0.484	0.478 0.474 0.478 0.477 0.478 0.470 0.471 0.476 0.453 0.475 0.450 0.465	0.001 0.001 0.003 0.002
67	Scituate, Mass.	1934 New	above HW MTL MTR	0.406	0.395 0.400 0.408 0.397 0.382 0.360 0.392 0.355 0.331 0.370 0.302 0.264 Hole	0.000 0.003 0.006 0.012 0.034
68	Chelsea, Mass.	1934 New	above HW MTL MTR	0.375	0.380 0.381 0.392 0.373 0.369 0.356 0.366 0.353 0.346 0.369 0.364 0.362	0.001 0.001 0.003 0.002
69	Charlton, Mass.	1931 New	MTL MTR	0.375	0.355 0.366 0.315 0.347 0.360 0.319 0.368 0.353 0.325 0.369 0.333 0.336	0.004 0.003 0.004 0.003
70	Lynn, Mass.	1931 New	above HW MTL MTR	0.484	0.486 0.489 0.490 0.483 0.482 0.487 0.484 0.486 0.473 0.483 0.474 0.447	0.000 0.000 0.002 0.003
71	Danvers, Mass.	1921 New	MTL	0.300	0.427 0.405 0.360	0.006
72	Portland, Maine	1932 New	above HW MTL MTR	0.375	0.375 0.377 0.374 0.376 0.366 0.367 0.375 0.376 0.362 0.371 0.378	0.000 0.001 0.001 0.000
73	Portland, Maine	1932 New	above HW MTL MTR	0.484	0.492 0.489 0.482 0.490 0.484 0.479 0.485 0.484 0.480 0.482 0.474 0.475	0.001 0.001 0.001 0.001

TABLE 1 (cont'd)

Group Number	Location	Year Installed & Condition	Form (1)	Minimal Thickness Inch	Average Measured Thickness Inch	Weighted Average Loss of Thickness Inch/yr. (2)
74	Portland, Maine	1932 New	above HW MTL MTR	0.484	0.503 0.507 0.505 0.501 0.506 0.498 0.501 0.503 0.496 0.466 0.462 0.420	0.000 0.000 0.000 0.006
75	Portland, Maine	1932 New	above HW MTL MTR	0.484	0.508 0.502 0.504 0.503 0.505 0.503 0.501 0.500 0.499 0.475 0.489 0.457	0.000 0.000 0.000 0.003
76	Portland, Maine	1932 New	above HW MTL MTR	0.484	0.495 0.497 0.492 0.492 0.492 0.487 0.490 0.493 0.487 0.492 0.492 0.487	0.000 0.001 0.000 0.001
77	Portland, Maine	1932 New	above HW MTL MTR	0.375	0.375 0.380 0.369 0.372 0.376 0.364 0.368 0.375 0.371 0.370 0.376 0.364	0.000 0.001 0.000 0.001

Part 2 - Beach Bulwarks						
78	Miami Beach, Fla.	1927 New	above HW MTL MTR	0.406	0.384 0.370 0.365 0.388 0.379 0.368 0.385	0.002 0.001 0.004
79	Miami Beach, Fla.	1927 New	above HW MTL MTR	0.406	0.372 0.393 0.400 0.379 0.372 0.370 Hole 0.000	0.002 0.004 0.011
80	Miami Beach, Fla.	1927 New	above HW MTL MTR	0.406	0.300 0.388 0.396 0.363 0.360 0.410 0.406 0.403 Hole 0.000	0.018 0.003 0.005 0.031
81	Miami Beach, Fla.	1930 New	above HW MTL MTR	0.406	0.418 0.360 0.360 0.360 0.417	0.000 0.010 0.000
82	Shore's Boulevard, Fla.	1927 New	above HW MTL MTR	0.406	0.275 0.275 Hole 0.000	0.004 0.061
83	Shore's Boulevard, Fla.	1927 New	above HW MTL MTR	0.406	0.191 0.321 0.224 0.294 0.329 0.341 0.389 0.306 Hole in flange (1st insp.)	0.003 0.009 0.012 0.004 0.037

TABLE 1 (cont'd)

Group Number	Location	Year Installed & Condition	Zone (1)	Nominal Thickness Inch	Average Measured Thickness Inch	Weighted Average Loss of Thickness Inch/yr. (2)
84	Baker's Manover, Fla.	1927 New	above SW	0.406	0.163	0.026
			above HW		0.236	0.018
			above SW		0.258	0.016
			HW		0.317	0.010
			above HW		Hole in Flange (1st loss) 0.037	
85	Hollywood, Beach, Fla.	1926 New	above HW	0.375	0.308	0.148
			above HW		0.326	0.004
			VTL		0.367	0.001
			above HW		Hole	0.000
86	Palm Beach, Fla.	1929 New	above SW	0.406	0.245	0.125
			above HW		0.330	0.268
			above HW		0.278	0.250
			HW		0.397	0.291
			above HW		Hole (1st measurement) 0.098	
87	Palm Beach, Fla.	1934 New	above HW	0.375	0.270	0.000
			above HW		0.297	0.202
			above HW		Hole	0.000
88a	Palm Beach, Fla.	1929 New	above HW	0.406	0.335	0.256
			above HW		0.336	0.121
			above HW		0.338	0.197
			above HW		0.338	0.209
88b	Palm Beach, Fla.	1929	above HW	0.406	0.387	0.354
			above HW		0.378	0.204
			above HW		0.356	0.274
			above HW		0.356	0.194
89	Palm Beach, Fla.	1929 New	above HW	0.250	0.213	0.299
			above HW		0.237	0.214
			above HW		0.261	0.244
			above HW		Hole	0.001
90a	Palm Beach, Fla.	1929 New	above HW	0.250	0.262	0.259
			above HW		0.265	0.257
			above HW		Hole	0.000
90b	Palm Beach, Fla.	1929 New	above HW	0.250	0.260	0.256
			above HW		0.262	0.256
			above HW		Hole	0.000
91	Palm Beach, Fla.	1929 New	above HW	0.406	0.406	0.378
			above HW		0.407	0.312
			above HW		0.405	0.361
92	Fort Stevens, Georgia	1931 New	above HW	0.375	0.364	0.293
			above HW		0.391	0.345
			above HW		Hole in flange	0.000
93	Fort Stevens, Georgia	1931 New	above HW	0.375	0.337	0.281
			above HW		0.360	0.378
			above HW		Hole	0.000
94a	Fort Stevens, Georgia	1931 New	above SW	0.375	0.329	0.264
			above HW		0.349	0.306
			above HW		Hole	0.000
94b	Fort Stevens, Georgia	1931 New	above HW	0.375	0.329	0.310
			above HW		0.360	0.276
95	Fort Stevens, Georgia	1931 New	above SW	0.375	0.296	0.299
			above SW		0.319	0.239
			above SW		Hole	0.000

TABLE 1 (cont'd)

Group Number	Location	Year Installed & Condition	Zone (1)	Nominal Thickness Inch	Average Measured Thickness Inch	Weighted Average Loss of Thickness Inch/yr. (2)
96	Fort Stevens, Georgia	1931 New	above HW above HW above HW	0.375 0.305 0.349 Hole	0.233 0.362 0.311 0.000	0.181 0.196 0.012 0.040
97	Fort Stevens, Georgia	1931 New	above HW above HW	0.375 0.301 0.370	0.224 0.194 0.346	0.000 0.025 0.275
98	Isle, New Jersey	1932 New	above HW above HW	0.375 0.304 0.347	0.323 0.313 0.299	0.075 0.046
99	Isle, New Jersey	1932 New	above SW above HW	0.375 0.366 0.360	0.335 0.316 0.329	0.095 0.006
100	Sea Bright, N. J.	1929 New	above SW above SW HW	0.375 0.321 0.315 Hole	0.278 0.178 0.157 0.000	0.035 0.024 0.028
101	Southampton, L. I., N. Y.	1933 Good	above HW	0.282	0.276 0.256	0.243
102	Southampton, L. I., N. Y.	1931 New	above HW	0.406	0.396 0.395	0.378
103	Shoreham, L. I., N. Y.	1933 New	above HW above HW	0.375 0.370	0.361 0.364	0.346
Part 3 - Groins and Jetties						
104	Clearwater Beach, Fla.	1934 New	HW	0.250	0.238 0.220	0.198
105	Clearwater Beach, Fla.	1934 New	above HW HW	0.250 0.251	0.241 0.252	0.257 0.260
106	Clearwater Beach, Fla.	1935 New	above HW	0.250	0.256 0.253	0.286
107	Clearwater Beach, Fla.	1927 New	VTL VTL #	0.406 0.368	0.403 0.399	0.399
108	Clearwater Beach, Fla.	1927 New	HW VTL	0.406 0.401	0.387 0.411	0.389
109	Clearwater Beach, Fla.	1927 New	HW	0.406	0.393	0.367
110	Clearwater Beach, Fla.	1927 New	HW	0.406	0.402	0.346
111	Clearwater Beach, Fla.	1927 New	HW VTL VTL VTL	0.406 0.423 0.373 0.344	0.400 0.402 0.397 0.350	0.402 0.398 0.306
					0.000	Hole in flange 0.026

TABLE 1 (cont'd)

Group Number	Location	Year Installed & Condition	Zone (1)	Nominal Thickness Inch	Average Measured Thickness Inch	Weighted Average Loss of Thickness Inch/Yr. (2)
112	Mead Beach, Fla.	1930 New	WH	0.406	0.418 0.401 0.400	0.001
113	Mead Beach, Fla.	1930 New	WH	0.406	0.408 0.409 0.401 0.400	0.001 0.001
114	Palm Beach, Fla.	1929 Good	WH	0.375	0.257 0.423 0.137	0.011
115	Palm Beach, Fla.	1929 Good	WH	0.375	0.234 0.262 0.206	0.003
116	Palm Beach, Fla.	1929 Good	MTL	0.375	0.556 0.299 0.222	0.004 0.003
117	Palm Beach, Fla.	1931 New	above WH MCH MTL	0.250	0.178 0.240 Hole (see inspection)	0.015 0.008 0.048
118	Palm Beach, Fla.	1931 New	WH	0.281	0.303 0.268 0.237	0.003
119	Palm Beach, Fla.	1931 New	WH MTL	0.250	0.222 Hole (see inspection)	0.003 0.007
120	Palm Beach, Fla.	1932 New	WH MTL	0.375 0.313	0.317 0.227 0.290 Hole in flange (see inspection)	0.003 0.010
121	Palm Beach, Fla.	1932 New	above WH	0.375	0.322 0.312 0.308	0.008
122	Palm Beach, Fla.	1937 New	MTL	0.375	0.336 0.367 0.333	0.006
123	Palm Beach, Fla.	1937 New	MCH MCH	0.375	0.364 0.307 Hole	0.004 0.006
124	Palm Beach, Fla.	1937 New	above WH	0.375	0.319 0.305 0.286	0.003
125	Palm Beach, Fla.	1937 New	MTL	0.375	0.313 0.314 0.286	0.008
126	Palm Beach, Fla.	1937 New	MTL MCH	0.375	0.354 0.351 0.295 Hole	0.008 0.001
127	Palm Beach, Fla.	1937 New	above WH	0.375	0.361 0.351 0.367	0.008
128	Palm Beach, Fla.	1937 New	MCH MTL	0.375	0.263 0.229 0.133 Hole	0.023 0.001
129	Palm Beach, Fla.	1937 New	MTL	0.375	0.338 0.334 0.298	0.011
130	Palm Beach, Fla.	1937 New	above WH	0.375	0.360 0.338 0.368	0.022
131	Palm Beach, Fla.	1937 New	WH MCH	0.375	0.378 0.366 0.364 Hole	0.004 0.009 0.040
132	Palm Beach, Fla.	1937 New	MTL	0.375	0.393 0.366 0.322	0.005
133	Palm Beach, Fla.	1937 New	above WH	0.367	0.317 0.317 0.313	0.003

TABLE 1 (cont'd)

Group Number	Location	Year Installed & Condition	Zone (1)	Nominal Thickness Inch	Average Measured Thickness Inch	Weighted Average Loss of Thickness Inch/Yr. (2)
134	Palm Beach, Fla.	1937 New	WH	0.367	0.479 0.364 0.272 Hole	0.033 0.000
135	Palm Beach, Fla.	1937 New	WH	0.367	0.568 0.528 0.520	0.006
136	Fort Scriven, Ga.	1931 New	above WH above WH above WH	0.375	0.287 0.271 0.152 0.299 0.275 0.239 Hole	0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
137	Fort Scriven, Ga.	1931 New	WH	0.375	0.365 0.362 0.339 0.217	0.003
138	Fort Scriven, Ga.	1931 New	WH MTL	0.375	0.374 0.370 0.359 0.345 Hole	0.002 0.000
139	Fort Scriven, Ga.	1931 New	WH MTL	0.375	0.366 0.343 0.364 0.305 Hole	0.001 0.000
140	Fort Scriven, Ga.	1931 New	above WH	0.375	0.351 0.345 0.330 0.290	0.006
141	Fort Scriven, Ga.	1931 New	above WH	0.375	0.339 0.240 0.103 0.000	0.006
142	Fort Scriven, Ga.	1931 New	WH MTL	0.375	0.393 0.352 0.326 0.308 Hole	0.005 0.000
143	Fort Scriven, Ga.	1931 New	MTL MCH	0.375	0.353 0.343 0.309 0.310 Hole	0.004 0.000
144	Pine Beach, S. C.	1933 New	WH WH MTL MCH	0.375	0.373 0.370 0.236 0.251 0.358 0.348 0.281 0.362 0.398 0.238 Hole	0.012 0.009 0.003 0.000
145	Pine Beach, S. C.	1933 New	WH WH MCH	0.375	0.372 0.338 0.269 0.317 0.371 0.360 0.317 0.368	0.018 0.005 0.008
146	Wilmington, N. C.	1933 New	above WH MCH	0.375	0.371 0.317 0.360	0.002 0.002
147	Wilmington, N. C.	1939 New	above WH MTL	0.375	0.380 0.368 0.382 0.388 0.362	0.002 0.001
148	Wilmington, N. C.	1939 New	WH MTL MCH	0.375	0.329 0.304 0.278 0.343 0.343 0.313 0.000 Hole	0.007 0.008 0.008
149	Long Branch, N. J.	1931 Good	WH	0.375	0.321 0.281	0.008
150	Banker Island, L.I., N. Y.	1935 Good	WH WH	0.406	0.371 0.361 0.298 0.338	0.009 0.006
151	Banker Island, L.I., N. Y.	1935 Good	WH WH	0.406	0.377 0.359 0.307 0.397	0.009 0.004
152	Banker Island, L.I., N. Y.	1936 New	WH MTL MCH	0.250	0.251 0.241 0.235 0.241 0.241 0.203 0.178 Hole in flange (see inspection)	0.001 0.005 0.006
153	Banker Island, L.I., N. Y.	1936 New	WH MTL MCH	0.250	0.244 0.238 0.234 0.211 0.241 0.219 0.211 Hole in flange (see inspection)	0.001 0.001 0.001

TABLE 2
REDUCTION OF PILED STATE SHEET PILING

Depth (ft)	West Florida Group				Stanford, Conn. Group #1			
	Thickness (in)	12/71	12/71	12/71	Thickness (in)	12/71	12/71	12/71
11.5					.530	.001		
11.0					.536	.000		
10.5					.525	.001		
10.0					.532	.000		
9.5					.527	.001		
9.0					.525	.001		
8.5					.529	.001		
8.0					.501	.002		
7.5					.509	.002		
7.0					.499	.003		
6.5					.491	.003		
6.0					.484	.004		
5.5	.370	.008			.456	.005		
5.0	.368	.008	.454	.004	.434	.005		
4.5	.366	.008			.448	.005		
4.0	.363	.008	.415	.007	.413	.007		
3.5	.358	.010			.423	.006		
3.0	.359	.009	.415	.006	.409	.008		
2.5	.394	.005			.438	.006		
2.0	.425	.002	.403	.003	.430	.003		
1.5	.420	.002			.475	.004		
1.0	.415	.003	.409	.000	.465	.004		
0.5	.418	.003			.477	.003		
0.0	.421	.003	.434	.003	.372	.013		
-0.5	.428	.003			.410	.007		
-1.0	.410	.004	.451	.002	.433	.006		
-1.5	.421	.003			.423	.006		
-2.0	.408	.005	.426	.005	.427	.006		
-2.5	.415	.003			.404	.005		
-3.0	.424	.003	.424	.006	.405	.008		
-3.5	.424	.003			.444	.005		
-4.0	.420	.003	.421	.005	.390	.012		
-4.5	.426	.002			.454	.004		
-5.0	.429	.002	.448	.004	.422	.007		
-5.5	.425	.002			.444	.005		
-6.0	.420	.003	.448	.004	.430	.006		
-6.5	.420	.003			.430	.006		
-7.0	.428	.002	.450	.004	.426	.008		
-7.5	.434	.002			.449	.003		
-8.0	.439	.001	.457	.003	.448	.006		
-8.5	.432	.002			.461	.004		
-9.0	.432	.002	.465	.002	.448	.004		
-9.5	.441	.000			.486	.001		
-10.0	.442	.002	.460	.003	.462	.003		
-10.5	.446	.000			.503	.002		
-11.0	.443	.000	.465	.002	.442	.005		
-11.5	.438	.002			.505	.002		
-12.0	.440	.001	.474	.000	.469	.000		
-12.5	.436	.000			.502	.002		
-13.0	.435	.001	.480	.001	.466	.002		
-13.5	.427	.002			.503	.002		
-14.0	.426	.002	.476	.001	.463	.003		
-14.5	.420	.005			.502	.002		
-15.0	.424	.001	.470	.002	.498	.003		
-15.5	.422	.001			.503	.002		
-16.0	.425	.002	.471	.002	.494	.002		
-16.5	.427	.002			.508	.002		
-17.0	.424	.003	.468	.004	.493	.002		
-17.5	.423	.003			.501	.002		
-18.0	.429	.000	.452	.003	.422	.004		
-18.5	.436	.001			.510	.002		
-19.0	.426	.003	.456	.003	.498	.002		
-19.5	.422	.003			.498	.002		
-20.0	.422	.003	.471	.003	.498	.003		
-20.5	.422	.003			.489	.003		
-21.0	.421	.002	.463	.003	.470	.002		
-21.5	.425	.002			.492	.003		
-22.0	.421	.002	.468	.002	.468	.002		
-22.5	.420	.002			.476	.001		
-23.0	.424	.002	.477	.002				
-23.5	.431	.002						
-24.0	.437	.001	.482	.001	.474	.001		
-24.5	.440	.001			.475	.001		
-25.0	.436	.002	.481	.001				
-25.5	.436	.002			.477	.001		
-26.0	.432	.003	.484	.002				
-26.5	.435	.002			.479	.001		
-27.0	.437	.001	.478	.001	.481	.001		
-27.5	.437	.001						
-28.0			.480	.000	.487	.000		
-28.5					.483	.001		

(1) The ground line has been at elevation = 27 foot top = number of pile.

Note: Four groups of piling were pulled during the period of investigation. Three were located at West, Florida, and one group was located at Stanford, Connecticut. All piled were of section having a web of variable thickness, increasing from center toward flange. Measurements at each elevation were made at the center of web, and at 1 inch, 2 inches, and 3 inches each side of the center, except for West Group 2, which was measured only at the center. Thickness measurements are averages of the 7 measurements, except for West Group 1. The maximum of the average measured thickness for the entire length was assumed to represent approximately the original thickness. The assumed original thicknesses are respectively 0.45 inch, 0.45 inch, 0.45 inch and 0.45 inch for West Groups 1, 2, 3 and the Stanford Group. Rates of loss are based on the difference between assumed of assumed thickness and the assumed original thickness over the period from date of installation to date of pulling. All elevations are referred to mean low water.

Summary

Average Annual Rates of Loss by Rate in Inch Per Year

Notes	West Florida Group			Stanford, Connecticut Group #1
	1	2	3	
Notes NEW	.008	.0055	.004	.006
2' above NEW to 2 1/4' above	.0056	.0065	.0033	.0026
2 1/4' to 1 1/2' above	.002	.004	.002	.0026
1 1/2' above to 1 1/4'	.007	.003	.011	.004
1 1/4' to ground line	.0062	.0058	.0044	.0028
Below ground line	.0070	.0015	.0003	.0022

TABLE 3

DETERIORATION OF STEEL SHEET PILING AT PRINCIPAL CAUSEWAYS

Part I - Harbor Bulkheads

A. Southern Region

Group Number	Cover (1)	Salt Spray (2)	Paint Protection (3)	Zone				Group Number	Cover (1)	Salt Spray (2)	Paint Protection (3)	Above Water Rate of loss in thousands of an inch/yr.	Below Water Rate of loss in thousands of an inch/yr.	WT. loss in thousands of an inch/yr.	WT. loss in thousands of an inch/yr.
				Above Water Rate of loss in thousands of an inch/yr.	WT. loss in thousands of an inch/yr.	WT. loss in thousands of an inch/yr.	WT. loss in thousands of an inch/yr.								
1	NP	N	T	24	11			57	NC	N	N	0	2		
	NC	N	T					58	NC	N	T	0	2		
2	NC	N	T	23			2		AC	N	T	0	2	3	2
	NC	N	T	22				60	NC	N	T	0	2	4	3
	NC	N	T					61	NC	N	T	0	2	4	3
3	NC	N	T	8			3	62	NC	N	T	0	2	4	3
4	NC	N	T	36				63	NC	N	T	0	2	4	3
	NC	N	T		10			64	NC	N	T	0	2	4	3
	NC	N	T		6			65	NC	N	T	0	2	4	3
5	NC	N	T		12	4	5	66	NC	N	T	0	2	4	3
6	NC	N	T		11	1			NC	N	T	0	2	4	3
7	NC	N	T	28				67	NC	N	T	0	2	4	3
	NC	N	T		17		4	68	NC	N	T	0	2	4	3
8	NC	N	T	27			1	69	NC	N	T	0	2	4	3
	NC	N	T		6			70	NC	N	T	0	2	4	3
9	NC	N	T		0			71	NC	N	T	0	2	4	3
10	NC	N	T		1	2		72	NC	N	T	0	2	4	3
11	NC	N	T		1	2			NC	N	T	0	2	4	3
12	NC	N	T		1	2		73	NC	N	T	0	2	4	3
13	NC	N	T		1	2		74	NC	N	T	0	2	4	3
14	NC	N	T		1	2		75	NC	N	T	0	2	4	3
15	NC	N	T	17				76	NC	N	T	0	2	4	3
	NC	N	T		11			77	NC	N	T	0	2	4	3
16	NC	N	T	6			0		NC	N	T	0	2	4	3
17	NC	N	T	11			0		NC	N	T	0	2	4	3
18	NC	N	T	10			0		NC	N	T	0	2	4	3
19	NC	N	T		9		0		NC	N	T	0	2	4	3
	NC	N	T		1		0		NC	N	T	0	2	4	3
20	NC	N	T	3			0		NC	N	T	0	2	4	3
21	NC	N	T	4			0		NC	N	T	0	2	4	3
22	NC	N	T		0		1		NC	N	T	0	2	4	3
	NC	N	T		1		1		NC	N	T	0	2	4	3

Part II - Beach Bulkheads

A. Southern Region

B. Northern Region

Group Number	Cover (1)	Salt Spray (2)	Paint Protection (3)	Above Water Rate of loss in thousands of an inch/yr.	Below Water Rate of loss in thousands of an inch/yr.	WT. loss in thousands of an inch/yr.	WT. loss in thousands of an inch/yr.	Group Number	Cover (1)	Salt Spray (2)	Paint Protection (3)	Above Water Rate of loss in thousands of an inch/yr.	Below Water Rate of loss in thousands of an inch/yr.	WT. loss in thousands of an inch/yr.	WT. loss in thousands of an inch/yr.
23	NC	N	T	18				78	NC	N	T	0	2	4	3
	NC	N	T		6			79	NC	N	T	0	2	4	3
24	NC	N	T	8			3		NC	N	T	0	2	4	3
25	NC	N	T	1					NC	N	T	0	2	4	3
26	NC	N	T	4			3	80	NC	N	T	0	2	4	3
27	NC	N	T	1			3		NC	N	T	0	2	4	3
28	NC	N	T	4			3		NC	N	T	0	2	4	3
29	NC	N	T	2			3	81	NC	N	T	0	2	4	3
	NC	N	T		4				NC	N	T	0	2	4	3
30	NC	N	T	2			4		NC	N	T	0	2	4	3
31	NC	N	T	0			4	82	NC	N	T	0	2	4	3
32	NC	N	T		2				NC	N	T	0	2	4	3
33	NC	N	T		3		1		NC	N	T	0	2	4	3
34	NC	N	T		2		3	83	NC	N	T	0	2	4	3
35	NC	N	T		1		4		NC	N	T	0	2	4	3
	NC	N	T		1				NC	N	T	0	2	4	3
36	NC	N	T		1		2	84	NC	N	T	0	2	4	3
37	NC	N	T		1		2		NC	N	T	0	2	4	3
38	NC	N	T		1		2		NC	N	T	0	2	4	3
39	NC	N	T		1		2		NC	N	T	0	2	4	3
40	NC	N	T		1		2	85	NC	N	T	0	2	4	3
41	NC	N	T		1		2		NC	N	T	0	2	4	3
42	NC	N	T		1		2		NC	N	T	0	2	4	3
	NC	N	T		1		2	86	NC	N	T	0	2	4	3
43	NC	N	T		1		2		NC	N	T	0	2	4	3
44	NC	N	T		1		2		NC	N	T	0	2	4	3
45	NC	N	T		1		2	87	NC	N	T	0	2	4	3
46	NC	N	T		1		2		NC	N	T	0	2	4	3
47	NC	N	T		1		2		NC	N	T	0	2	4	3
	NC	N	T		1		2	88	NC	N	T	0	2	4	3
48	NC	N	T		1		2		NC	N	T	0	2	4	3
	NC	N	T		1		2	89	NC	N	T	0	2	4	3
49	NC	N	T		1		2		NC	N	T	0	2	4	3
	NC	N	T		1		2	90	NC	N	T	0	2	4	3
50	NC	N	T		1		2		NC	N	T	0	2	4	3
	NC	N	T		1		2	91	NC	N	T	0	2	4	3
51	NC	N	T		1		2		NC	N	T	0	2	4	3
52	NC	N	T		1		2		NC	N	T	0	2	4	3
53	NC	N	T		1		2	92	NC	N	T	0	2	4	3
54	NC	N	T		1		2		NC	N	T	0	2	4	3
55	NC	N	T		1		2		NC	N	T	0	2	4	3
56	NC	N	T		1		2	93	NC	N	T	0	2	4	3
57	NC	N	T		1		2		NC	N	T	0	2	4	3

(1) Cover by sand, earth or other material; N indicates no cover; P indicates that area was covered at area inspection but not at other; T indicates that area was covered at all inspections. The letters are used, and for same purpose as the piling.

(2) N indicates heavy; S indicates light; B indicates none.

(3) R indicates no rusting; F indicates pitting; H indicates rust.

Part 3 - Groins and Jetties

a. Southern Region

<u>Cover</u>	<u>Above MHW</u>	<u>MHW</u>	<u>MTL</u>	<u>MLW</u>
NN	41/2 = 21	56/8 = 7.0	368/9 = 41	77/3 = 26
NP		25/3 = 8.3	14/2 = 7	56/2 = 28
NC	93/6 = 16	20/4 = 5.0	152/8 = 19	219/6 = 37
PP		8/2 = 4.0		59/2 = 30
PC	6/2 = 3.0	6/2 = 3.0	12/2 = 6	23/1 = 23
CC	8/3 = 2.7	1/2 = 0.5		9/2 = 4.5

Paint

N	113/10 = 11	102/15 = 6.8	491/13 = 38	303/9 = 34
I	35/3 = 12	14/6 = 2.3	55/8 = 6.9	140/7 = 20

All in Southern Region	148/13 = 11	116/21 = 5.5	546/21 = 26	443/16 = 28
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All Zones in Southern Region	1253/71 = 18
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b. Northern Region

Cover

NN	2/1 = 2	39/7 = 5.6	1/1 = 1	28/1 = 28
PC	2/1 = 2	2/1 = 2.0		
NC		7/1 = 7.0	108/5 = 22	

Paint

N	2/1 = 2	46/7 = 6.6	28/1 = 28	28/1 = 28
I	2/1 = 2	2/2 = 1	81/5 = 16	

All in Northern Region	4/2 = 2	48/9 = 5.3	109/6 = 18	28/1 = 28
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All Zones in Northern Region	189/18 = 11
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All Groins and Jetties	152/15 = 10	164/30 = 5.5	655/27 = 24	471/17 = 28
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Average for all Zones	1442/89 = 16
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DURABILITY OF STEEL SHEET PILING
IN SHORE STRUCTURES

APPENDIX A

MISCELLANEOUS DATA

Additional data obtained during the investigation are assembled in this appendix, arranged by group number as in Table 1. Unnumbered groups for Miami and Bakers Haulover, Florida, and Cape May and Cape May Point, New Jersey, arranged in geographical order, are also included. All elevations are referred to local mean low water.

Part 1 - Harbor Bulkheads

Group
Number

- 1 Location - Tampa, Florida, Davis Island Hospital facing Seddon channel.
- Exposure - Protected from waves except from passing boats.
- Condition of Water - Pollution by industrial waste and domestic sewage causes deposit of scum on the piles in high tide zone.
- Marine Life - Oysters, barnacles, and green algae.
- Mean Tidal Range - 1.8 feet
- Painting - Some years previous to 1st inspection. Scraped and painted shortly after 1st inspection.
- Condition - By 19.1 years, rust scale 1/4 inch thick on upper part of piles, large holes in webs at tops of piles where not protected by backfill.
- 2-3 Location - Tampa, Florida, 4 miles SE on E side Hillsboro Bay, wharf of American Cyanamide Company.
- Steel - Copper bearing.
- Exposure - Waves of Hillsboro Bay, fetch W 4 miles, SW 10 miles.
- Marine Life - Oysters, mussels and barnacles.
- Mean Tidal Range - 1.8 feet
- Cover - Group 2 faces W, exposed to atmosphere on both sides above MLW. Group 3 faces S, protected by fill on land side.

Painting - Bituminous paint when installed. Forced off by rust in spots by 6.3 years. Almost completely gone by 10.4 years.

Condition - Group 2, by age 16.3 years, holes in flanges at tops of piles.

- 4 Location - Sarasota, Florida, NE corner of City Island near inner end of New Pass, W side of Sarasota Bay.

Exposure - Waves from NE in Sarasota Bay, fetch 3 miles.

Marine Life - Oysters, barnacles and mussels.

Mean Tidal Range - 1.3 feet.

Cover - Tops not protected by backfill.

Condition - By 20.4 years, tops in bad condition, large areas of webs entirely gone, rust nearly 1/2 inch thick on remaining parts.

- 5 Location - Fort Myers, Florida, E shore of Caloosahatchee River, 2 miles S of Fort Myers, estate of Dr. V. Piatti.

Steel - Copper bearing.

Exposure - Waves in river, fetch N and W, 1 to 2 miles.

Marine Life - Barnacles, oysters and green algae.

Mean Tidal Range - 1 foot.

Cover - Front only exposed, top protected by concrete cap.

Condition - By 17.1 years, rust 1/2 inch thick on upper part of structure.

- 6 Location - Miami Beach, Florida, Corps of Engineers bulkhead N side of entrance channel to Miami Harbor.

Exposure - Waves in Biscayne Bay, fetch SW 0.6 mile.

Condition of Water - Records of USC & GS Feb-Jun 1940, mean density corrected to 15⁰ C 1.0268 (salinity 36.0).

Mean Tidal Range - 2.5'.

Painting - Shop coat of coal tar base paint.

Condition - By 5.2 years, paint completely gone, rust about 1/3 inch thick.

Group
Number

Un- Location - Miami, Florida, City Piers
number Group A - near shore on S side of S pier
ed Group B - Near outer end on S side of S pier
Group C - Near outer end on N side of S pier

Exposure - Little wave or current action.

Condition of Water - Sea water, probably moderately polluted by domestic sewage. Oily scum found on piles.

Mean Tidal Range - 1.5 feet.

Construction - Built latter part of 1925. Driven into mud, sand and soft rock. Sand and rock both consisted largely of shells. Backfill of same material.

Marine Life - Chiefly oysters.

Remarks - Piles pulled in 1936, about 10 years after installation. Data on measurements of entire lengths given in Table 2.

7 Location - Fort Pierce, Florida, W bank of Indian River, City pier bulkhead 130 feet N of highway bridge across Indian River.

Exposure - Waves in Indian River, fetch 1/2 mile.

Marine Life - Oyster, barnacles and green algae.

Mean Tidal Range - 0.7 feet.

Condition - By 11.3 years, holes in webs at elevation +2.5 feet, age 17.2 years, large areas of webs completely gone down to elevation +1.5 feet.

8 Location - Jacksonville, Florida, 6 miles NE of Jacksonville on N bank of Broward River near confluence with St. Johns River, Brooks Scanlon Lumber Company bulkhead.

Exposure - Small waves of St. Johns River.

Condition of Water - Salt water diluted with fresh water, polluted by domestic sewage.

Mean Tidal Range - 2 feet.

Condition - By 22 years, tops of piles reduced to knife-edge thickness (piles pulled shortly thereafter).

Group
Number

- 9 Location - Jacksonville, Florida, E bank of McCoys Creek near confluence with St. Johns River 60 feet from S end of bulkhead.

Steel - Copper bearing.

Exposure - Not exposed to waves.

Condition of Water - See Group 8 preceding. Pollution also by diesel oil.

Mean Tidal Range - 0.9 feet.

Cover - Both sides exposed to atmosphere.

Painting - Asphalt paint previous to installation.

Condition - By 6 years, paint completely gone, age 17.3 years, 1/16 inch of rust on backs of piles.

- 10 Location - Jacksonville, Florida in same bulkhead as Group 9 but 90' from S end.

Steel - Copper bearing

Cover - Exposed on front only.

Painting - Original asphalt coating remained in good condition under a heavy coating of oil (pollution) through the 3d inspection, age 17.3 years.

- 11 Location - Jacksonville, Florida, W bank of St. Johns River near 17th Street and Talleyrand Avenue, Municipal Terminal bulkhead.

Exposure - Not exposed to waves.

Condition of Water - See Group 8.

Marine Life - 1st inspection, age 19 years none. 3d inspection, age 30.3 years, barnacles and green algae.

Mean Tidal Range - 1.4 feet.

Painting - Shop coat and repainting several times previous to 1st inspection, none thereafter.

Condition - At 19 years, no rust, at 30.3 years, heavy rust.

Group
Number

- 12 Location - Charleston, S. C., W bank of Shipyard Creek, downstream (S) end of Gulf Oil Corporation wharf.
- Exposure - Not exposed to waves.
- Condition of Water - Salt water diluted with fresh water, polluted with domestic sewage, also affected by fill of discarded bricks from acid towers of adjacent fertilizer plant on downstream side. H_2S escaped from backfill.
- Marine Life - Heavy growth of oysters and barnacles.
- Mean Tidal Range - 5.3 feet.
- Painting - Shop coat of acid-free tar, 1 coat of black paint after driving. By 7.2 years, paint gone except near top of piles, age 16.3 years, paint entirely gone.
- Condition - By 16.3 years rust about 1/4 inch thick, steel badly pitted in zone below H. W.
- 13 Location - Charleston, S. C., 500 feet upstream from Group 12.
- Condition of Water - Same as for Group 12, oil scum noted at 3d inspection.
- 14 Location - Charleston, S. C., 1,000 feet upstream from Group 12.
- 15 Location - Charleston, S. C., E side of Ashley River at entrance to Municipal Yacht Basin.
- Exposure - Not exposed to waves.
- Marine Life - Oysters, barnacles and green algae.
- Mean Tidal Range - 5.2 feet.
- Condition - Piles second hand, badly rusted when installed, rust about 1/2 " thick. By 5.2 years after installation, large holes in upper part of piles. Age 11.2 years, upper 2 feet of webs gone, 3/4 inch holes previously drilled in LW zone enlarged to 2 1/2 inch diameter.
- 16 Location - Kure Beach, N. C., Ethyl-Dow Chemical Company intake 13 feet wide x 200 feet long between 2 cellular jetties, 180' from ocean end on intake side of S jetty.

Group
Number

Exposure - Not exposed to waves. Some currents, piles possibly subject to abrasion by moving sand.

Condition of Water - Normal sea water. Heavy deposit of salts on piling.

Marine Life - Mussels, oysters, seaweed.

Mean Tidal Range - 4.2 feet (in ocean).

- 17 Location - Kure Beach, N. C., Ethyl-Dow Chemical Company stilling basin 80 feet square W of intake, S wall of basin near E end.

Exposure - Not exposed to waves or high water velocities.

Marine Life - Heavy growth of oysters, barnacles, mussels and algae.

Painting - Coat of primer and 3 coats black paint 2 years after installation.

Condition - Age 3.5 years, paint good. By 6.5 years, paint being forced off by scale, rust about 1/4 inch thick, piling exposed to water on both sides due to enlargement of basin. Back side unpainted, covered with heavy rust. Piles removed before 3d inspection.

- 18 Location - Kure Beach, N. C., Ethyl-Dow Chemical Company, near center of S wall of stilling basin.

Painting - Water side painted with 4 coats aluminum paint. History same as for Group 17.

- 19 Location - Kure Beach, N. C., Ethyl-Dow Chemical Company, baffle wall just E of screens on W side of stilling basin.

Marine Life - Barnacles, mussels, oysters and seaweed.

- 20 Location - Kure Beach, N. C., Ethyl-Dow Chemical Company, near center of N wall of stilling basin.

Marine Life - Barnacles, mussels, oysters and algae.

- 21 Location - Kure Beach, N. C., Ethyl-Dow Chemical Company wharf on E bank Cape Fear River.

Exposure - Small waves.

Group
Number

Condition of Water - Salinity varies from sea water when fresh water runoff is low to moderate dilution. Waste products of bromine extraction process discharged 150 feet downstream caused water to be moderately acid. p H in 1940, 7.2 to 7.6 at surface, 3.1 to 3.2 at bottom.

Marine Life - Light growth of barnacles at the bottom.

Mean Tidal Range - 3.9 feet.

- 22 Location - Wilmington, N. C., W bank of Cape Fear River, Corps of Engineers bulkhead.

Exposure - Not exposed to waves.

Condition of Water - Fresh except during periods of extremely low runoff. Oil scum below HW line. High sulfur content in water precolating through cinder backfill.

Mean Tidal Range - 3.2 feet.

Condition - By age 11 years, corrosion about holes previously drilled, from which plugs had been lost.

- 23 Location - Point Pleasant, New Jersey, S wall of channel at Manasquan Inlet.

Exposure - Heavy waves at times.

Marine Life - Chiefly mussels.

Mean Tidal Range - 4 feet.

Condition - Piles removed in 1940.

- 24 Location - Belmar, New Jersey, Shark River, outer wall of N pier of Yacht basin, 60 feet from end.

Exposure - Small waves only.

Marine Life - Barnacles and mussels.

Mean Tidal Range - 4 feet.

Condition - Piles removed in 1940.

Painting - Asphalt type paint when installed. At 6 years, being forced off by rust, by 14.7 years, completely gone.

Group
Number

- 25 Location - Harrison, New Jersey, Passaic River 5 miles above mouth,
 bulkhead of Otis Elevator Company.
- Exposure - Not exposed to waves. Substantial tidal and fresh water
 currents.
- Condition of Water - Variable salinity, heavily polluted with
 domestic and industrial sewage.
- Marine Life - Barnacles and mussels.
- Mean Tidal Range - 5 feet.
- Painting - Tar coating. At 8 years good condition on upper parts,
 but nearly gone near water line.
- 26 Location - New York, New York, Harlem River at foot of 153d
 Street.
- Exposure - Not exposed to waves. Tidal currents substantial.
- Condition of Water - Moderately diluted polluted sea water.
- Mean Tidal Range - 4.9 feet.
- 27 Location - Brooklyn, New York, Gowanus Creek at foot of 24th Street,
 slip of Todd Dry Dock Engineering and Repairing Corporation.
- Steel - Copper bearing.
- Exposure - Not exposed to waves.
- Condition of Water - Moderately diluted polluted sea water.
- Mean Tidal Range - 4.4 feet.
- 28 Location - Brooklyn, New York, Erie Basin, Robbins Dry Dock of Todd
 Shipyards Corporation.
- Exposure - Not exposed to waves.
- Condition of Water - Moderately diluted, polluted sea water.
- Mean Tidal Range - 4.4 feet.
- 29 Location - Queens, New York, Newtown Creek, wharf of National Sugar
 Refining Company.
- Exposure - Not exposed to waves. Substantial tidal currents.
- Condition of Water - Moderately diluted, polluted sea water.
- Painting - Traces of asphalt paint on piles.
- Mean Tidal Range - 4.2 feet.

Group
Number

- 30 Location - Long Island City, Queens, New York, about 2 miles above mouth on Newtown Creek, wharf of Meehan Building Materials Company.
- Exposure - Not exposed to waves.
- Condition of Water - Moderately diluted, polluted sea water.
- Mean Tidal Range - 4.2 feet.
- 31 Location - New York, N. Y. East River, N side of Rikers Island, New York City Department of Correction.
- Exposure - Waves in East River, fetch 1/2 mile, strong tidal currents.
- Condition of Water - Moderately diluted, polluted sea water.
- Mean Tidal Range - 6.3 feet.
- 32 Location - Island Park, Long Island, New York, Reynolds Channels, bulkheads of Petroleum Heat and Power Company.
- Exposure - Not exposed to waves. Substantial tidal currents.
- Condition of Water - Moderately diluted sea water.
- Marine Life - Green algae and barnacles.
- Mean Tidal Range - 3.9 feet.
- Painting - Painted at age 6 years with red lead and a paint of which the base is a metal ester of a polymerized oil. Painted at age 11 years. Paint in poor condition at 8.2 years. Paint being forced off by heavy rust scales by 16.9 years.
- 33 Location - Canoe Place, Long Island, New York, west wall of Shinnecock Canal near lock.
- Steel - Copper bearing.
- Exposure - Not exposed to waves.
- Marine Life - Barnacles and sea fern.
- Mean Tidal Range - 0.3 feet, larger changes due to meteorological conditions.
- Painting - At age 5 years, painted with red lead and asphalt paint. Nearly gone by 15.2 years.

Group
Number

- 34 Location - Roslyn, Long Island, New York, Hempstead Harbor, Wal-
 bridge Boat House.
- Exposure - Not exposed to waves.
- Condition of Water - Moderately diluted, polluted sea water.
- Marine Life - Barnacles and green algae.
- Mean Tidal Range - 7.3 feet.
- Painting - Red lead and a gray paint when installed.
- 35 Location - Glen Cove, Long Island, New York, N side of entrance to
 Glen Cove Creek from Hempstead Harbor.
- Exposure - Not exposed to waves. Moderate tidal currents.
- Condition of Water - Moderately diluted sea water.
- Marine Life - Barnacles.
- Mean Tidal Range - 7.3 feet.
- 36 Location - Glen Cove, Long Island, New York, near inner end of
 same bulkhead as Group 35.
- Cover - Backfill does not extend above L.W.
- 37 Location - Greenwich, Connecticut, E. side of Greenwich Harbor,
 wharf of Maher Brothers Corporation.
- Exposure - Very small waves and currents only.
- Condition of Water - Moderately diluted, polluted sea water.
- Marine Life - Barnacles and mussels.
- Mean Tidal Range - 7.4 feet.
- Painting - Shop coat, gone by 13 years.

Group
Number

- 38 Location - Stamford, Connecticut, W side, W. Branch, Stamford Harbor, wharf of Genovese Coal and Masons' Material Company.
- Exposure - Little affected by waves and currents.
- Condition of Water - Moderately diluted, polluted sea water.
- Mean Tidal Range - 7.2 feet.
- Painting - Original field coat in poor condition by 8 years.
- 39 Location - Stamford, Connecticut, E side, W Branch, Stamford Harbor, wharf of Stamford Gas and Electric Company.
- Exposure - Little affected by waves. Substantial tidal current
- Condition of Water - Moderately diluted, polluted sea water.
- Marine Life - Barnacles and mussels.
- Mean Tidal Range - 7.2 feet.
- Painting - Coat of coal tar applied at age 1 year in fair condition at 3 years, nearly gone by 12 years.
- 40 Location - Stamford, Connecticut, 125 feet N of Group 39.
- Exposure - Slightly affected by waves and currents.
- Condition of Water - Moderately diluted, polluted sea water.
- Marine Life - Barnacles, mussels and oysters.
- Mean Tidal Range - 7.2 feet.
- Painting - Coat of coal tar applied at age 12 years.
- Remarks - Piles pulled in 1941, 18 years after installation. Data on measurements of entire lengths given in Table 2.
- 41 Location - Norwalk, Connecticut, E side Norwalk River, wharf of Meeker Coal Company.
- Exposure - Little affected by waves. Some tidal current.
- Condition of Water - Moderately diluted, polluted sea water.
- Marine Life - Algae and barnacles.
- Mean Tidal Range - 7.1 feet.

Group
Number

- Painting - Shop coat, coat of red lead at age 3 years, coats of aluminum paint at ages 5, 9 and 11 years.
- 42 Location - Norwalk, Connecticut, E channel Norwalk Harbor, wharf of Frederick Fields Estate.
- Exposure - Some waves and currents.
- Condition of Water - Moderately diluted, polluted sea water.
- Marine Life - Barnacles and mussels.
- Mean Tidal Range - 7.1 feet.
- Painting - Asphalt paint applied after driving nearly gone by 8 years.
- 43 Location - Bridgeport, Connecticut, W side, E Branch, Cedar Creek, wharf of Silliman and Godfrey Company.
- Exposure - Not exposed to waves or currents.
- Mean Tidal Range - 6.8 feet.
- Painting - Shop coat nearly gone by 5 years.
- 44 Location - Bridgeport, Connecticut, W side, E Branch, Cedar Creek, wharf of Socony-Vacuum Oil Company.
- Exposure - Not exposed to waves or currents.
- Mean Tidal Range - 6.8 feet.
- Painting - Shop coat nearly gone by age 5.6 years. Painted several times with a metal paint between 1st and 3d inspections.
- 45 Location - Bridgeport, Connecticut, wharf of United Illuminating Company.
- Exposure - Some waves. Substantial tidal current.
- Condition of Water - Moderately diluted, polluted sea water.
- Marine Life - Chiefly algae.
- Mean Tidal Range - 6.8 feet.
- Painting - None.
- 46 Location - Devon, Connecticut, E side Housatonic River, wharf of Gulf Oil Company.

Group
Number

- Exposure - Not exposed to waves. Considerable current.
- Condition of Water - Sea water, considerably diluted, especially at times of large fresh water runoff. Heavily polluted by domestic sewage and industrial wastes.
- Mean Tidal Range - 5.3 feet.
- Painting - Shop coat only, little remained by 9 years.
- 47-48 Location - New Haven, Connecticut, West River, wharf of American Oil Company.
- Exposure - Some waves and currents.
- Condition of Water - Moderately diluted, polluted sea water.
- Marine Life - Algae and barnacles.
- Mean Tidal Range - 6.3 feet.
- Painting - Shop coat only, nearly gone by 10 years.
- 49 Location - New Haven, Connecticut, E side, W Branch, Mill River, wharf of United Illuminating Company.
- Exposure - Not exposed to waves or appreciable currents.
- Condition of Water - Moderately diluted, polluted sea water.
- Marine Life - Algae and barnacles.
- Mean Tidal Range - 6.3 feet.
- Painting - Asphalt paint every 2 years to 1937, age 9 years, not painted thereafter. Paint in poor condition by age 12 years.
- 50 Location - New Haven, Connecticut, E side Mill River, City Playground bulkheads.
- Exposure - Little affected by waves or currents.
- Condition of Water - Moderately diluted, polluted sea water.
- Marine Life - Algae and barnacles.
- Mean Tidal Range - 6.3 feet.
- Painting - None.

Group
Number

- 51 Location - New Haven, Connecticut, E side New Haven Harbor, bulk-head of T. A. D. Jones and Company.
- Exposure - Some waves and currents.
- Condition of Water - Moderately diluted, polluted sea water.
- Marine Life - Algae.
- Mean Tidal Range - 6.3 feet.
- Painting - Asphalt paint at age 2 years and with red lead and varnish residue every 2 years during inspection period.
- 52 Location - Branford, Connecticut, W side Branford River, wharf of Malleable Iron Fittings Company.
- Steel - Copper bearing.
- Exposure - No waves, minor tidal currents.
- Condition of Water - Moderately diluted sea water. Pickling acids discharged nearby until 1939, age 5 years.
- Marine Life - Algae and barnacles.
- Mean Tidal Range - 5.9 feet.
- Painting - Painted when installed, little remained by 3 years.
- 53 Location - Middletown, Connecticut, W bank Connecticut River, wharf of Connecticut Power Company.
- Steel - Copper bearing.
- Exposure - No waves. Currents vary with volume of fresh water discharge.
- Condition of Water - Almost fresh, probably minor intrusions of salinity at low river stages. Heavy pollution by domestic sewage and industrial wastes reduced between 1937 and 1940.
- Mean Tidal Range - About 2 feet, but larger fluctuations of level are caused by variations in discharge.
- Painting - Shop coat nearly gone by 5 years.
- 54 Location - New London, Connecticut, W side Shaws Cove, wharf of Calamari Brothers Company

Group
Number

Exposure - No waves or currents.

Condition of Water - Moderately diluted, polluted sea water.

Marine Life - Algae and barnacles.

Mean Tidal Range - 2.5 feet.

Painting - Shop coat. Painted with red lead and blue paint in 1937, age 1 year.

- 55 Location - Point Judith, R. I., W side of entrance to Point Judith Pond on State Pier No. 4.

Exposure - No waves. Strong tidal currents in channel.

Condition of Water - Sea water.

Marine Life - Algae, barnacles, mussels and kelp.

Mean Tidal Range - 3.1 feet.

Cover - The lower zone of measurements was covered with sand at the 3d inspection.

- 56 Location - Newport, Rhode Island, E side Goat Island, Torpedo Station bulkhead.

Steel - Copper bearing.

Exposure - Little wave action or currents.

Condition of Water - Sea water. Fuel Oil pollution coated piles to H.W.

Marine Life - Brown kelp.

Mean Tidal Range - 3.5 feet.

- 57 Location - Newport, Rhode Island, E side Newport Harbor, Navy Landing bulkhead.

Steel - Copper bearing.

Exposure - Little wave action or currents.

Condition of Water - Sea water.

Marine Life - Green algae, barnacles and kelp.

Mean Tidal Range - 3.5 feet.

Group
Number

- 58 Location - Newport, Rhode Island, E side Newport Harbor, wharf of E. S. Peckham Coal and Ice Company.
- Exposure - Small waves and moderate tidal currents.
- Condition of Water - Sea water.
- Marine Life - Algae and barnacles.
- Mean Tidal Range - 3.5 feet.
- Painting - None
- 59-60 Location - New Bedford, Massachusetts, E side of Fish Island, 59 and 60 on E and W sides respectively of wharf of David Duff and Sons.
- Exposure - Small waves and light currents.
- Condition of Water - Sea water.
- Marine Life - Algae and barnacles.
- Mean Tidal Range - 3.7 feet.
- Painting - Asphalt paint every year.
- 61 Location - New Bedford, Massachusetts, W side of harbor, N side wharf of New Bedford Gas and Edison Light Company.
- Exposure - Little wave action. Some tidal currents.
- Condition of Water - Sea water
- Mean Tidal Range - 3.7 feet.
- Painting - Dipped in coal tar before driving. Coating almost gone by 14 years.
- 62 Location - Woods Hole, Massachusetts, W side Little Harbor wharf of U. S. Coast Guard Lighthouse Depot.
- Steel - Copper bearing.
- Exposure - Some wave action. Minor tidal currents.
- Marine Life - Green algae and barnacles.
- Mean Tidal Range - 1.5 feet.

Group
Numbers

- Painting - Annually with red lead to 1935, age 4 years, asphalt paint in 1936 and 1937, none thereafter.
- 63 Location - Bourne, Massachusetts, NW side Cape Cod Canal, wharf of State Pier.
- Steel - Copper bearing.
- Exposure - Not exposed to waves or currents.
- Condition of Water - Sea water.
- Marine Life - Barnacles, gray algae, mussels and kelp.
- Mean Tidal Range - 4 feet.
- 64 Location - Boston, Massachusetts, W side Boston Light Station outside entrance to Boston Harbor.
- Steel - Copper bearing.
- Exposure - Exposed to minor waves from W. Substantial tidal currents.
- Condition of Water - Sea water.
- Marine Life - Heavy growth barnacles and green algae.
- Mean Tidal Range - 9 feet.
- Painting - Red lead after driving, black paint annually over barnacles and rust until 1941, age 9 years.
- 65 Location - Boston, Massachusetts, Army Base bulkhead on Reserved Channel near L Street bridge.
- Exposure - Little wave or current action.
- Condition of Water - Sea water polluted by industrial waste, H_2S escaped from backfill.
- Marine Life - Algae and barnacles.
- Mean Tidal Range - 9.4 feet.
- Painting - Asphalt paint when installed.
- 66 Location - Boston, Massachusetts, E end Army Base bulkhead on Main Channel.

Group
Number

- Exposure - Some waves and tidal currents.
- Condition of Water - Sea water, polluted by industrial waste.
- Marine Life - Algae, barnacles and seaweed.
- Mean Tidal Range - 9.4 feet.
- Painting - Asphalt emulsion paint after driving.
- 67 Location - South Boston, Massachusetts, S side Reserved Channel, bulkhead of White Fuel Company
- Exposure - Not exposed to waves or currents.
- Condition of Water - Sea water, polluted by industrial waste.
- Marine Life - Algae and barnacles.
- Mean Tidal Range - 9.4 feet.
- Condition - Heavy deposit of coal dust on piles, as thick as 2.5 inches mean tide zone. Strong flow of water from holes in L.W. zone. Plugs had fallen from some holes drilled at 1st inspection and holes had about doubled in size by age 12 years. By age 12 years a hole about 1 foot x 1.5 foot at elevation 3' was found where web of pile had rusted through. It was not near any drilled hole.
- 68 Location - Chelsea, Massachusetts, N-side Chelsea River, wharf of U. S. Coast Guard (lighthouse depot).
- Exposure - Little wave action. Minor tidal currents.
- Condition of Water - Sea water, grease, scum and oil on surface.
- Marine Life - Algae and barnacles.
- Mean Tidal Range - 9.8 feet.
- Painting - Red lead when installed (1934) and black paint 1937.
- 69 Location - Charlestown, Massachusetts, S side South Mystic River, wharf of Glendale Coal Company.
- Exposure - Little wave or current action.
- Condition of Water - Sea water, polluted with industrial waste, scum and grease on surface.
- Marine Life - Algae, barnacles and seaweed.

Group
Number

Mean Tidal Range - 9.7 feet.

Cover - Piles are in front of granite retaining wall; no fill in back; water has free access to back of piling.

- 70 Location - Lynn, Massachusetts, SW side of slip of Lynn Gas and Electric Company, 100 feet from outer end.

Steel - Copper bearing.

Exposure - Not exposed to waves or currents.

Condition of Water - Sea water, oil pollution.

Marine Life - Algae, barnacles and kelp.

Mean Tidal Range - 9.2 feet.

Painting - Shop coat of acid-free tar was gone by 1st inspection age 6 years.

- 71 Location - Salem, Massachusetts, bulkhead of Salem Electric Light Company.

Exposure - Not exposed to waves or currents.

Condition of Water - Sea water polluted with industrial waste.
Hot water from plant falls into river 8 feet upstream from piling. Water temperatures at piling in summer were 78° and 88° F.

Marine Life - Moss.

Mean Tidal Range - 9 feet.

- 72 Location - Portland, Maine, S side Fore River, SW side wharf of U. S. Coast Guard (Lighthouse Depot) 210 feet from shore end of bulkhead.

Steel - Copper bearing.

Exposure - Little wave or current action.

Condition of Water - Sea water, polluted by sewage and industrial waste.

Marine Life - Barnacles and periwinkles.

Mean Tidal Range - 8.9 feet.

Group
Number

Painting - Several types 1932 to 1935, crankcase oil in 1935 and 1936, asphalt emulsion in 1937, none thereafter during inspection period.

- 73 Location - Portland, Maine, S side Fore River, SW side upstream pier of U. S. Coast Guard (Lighthouse Depot) 69 feet from shore end.

Steel - Copper bearing.

Exposure - Small waves and light currents.

Condition of Water - Same as Group 72. H_2S escaped from backfill.

Marine Life - Green algae, barnacles and kelp.

Painting - Same as Group 72.

- 74 Location - Portland, Maine, S side Fore River, outer end of upstream pier of U. S. Coast Guard (Lighthouse Depot).

Steel - Copper bearing.

Exposure - Wave action from NE through river mouth. Moderate tidal currents.

Condition of Water - Same as Group 73.

Marine Life - Same as Group 73.

Painting - Same as Group 72.

- 75 Location - Portland, Maine, S side Fore River, between piers of U. S. Coast Guard (Lighthouse Depot).

Steel - Copper bearing.

Exposure - Not exposed to waves or currents.

Condition of Water - Same as Group 73.

Marine Life - Same as Group 73.

Painting - Same as Group 72.

- 76 Location - Portland, Maine, S side Fore River, NE side upstream pier of U. S. Coast Guard (Lighthouse Depot), 150 feet from shore end.

Steel - Copper bearing.

Group
Number

Exposure - Wave action from NE through river mouth. Some tidal currents.

Condition of Water - Same as Group 72.

Marine Life - Chiefly green algae and barnacles.

Painting - Same as Group 72.

- 77 Location - Portland, Maine, S side Fore River, NE side of wharf of U. S. Coast Guard (Lighthouse Depot) 206 feet from shore end.

Steel - Copper bearing.

Exposure - Same as Group 76.

Condition of Water - Same as 72.

Marine Life - Green algae and barnacles.

Painting - Same as Group 72.

Part 2 - Beach Bulkheads

- 78 Location - Miami Beach, Florida, about 90 feet S of 22d Street.

Painting - Bituminous paint when installed. A thin priming coat was applied cold followed by a heavy finishing coat applied hot.

Condition - Heavy rust at age 9 years.

- 79 Location - Miami Beach, Florida, at foot of 22d Street.

Painting - Same as Group 78.

Condition - Paint had been forced off piling by heavy rust by age 9 years. Webs at top of piles beginning to rust out at age 13.3 years, were rusted out for 6 inches to 8 inches from top by age 19.2 years.

- 80 Location - Miami Beach, Florida, at foot of 30th Street.

Painting - Same as Group 78.

Condition - Paint had been forced off piling by heavy rust by age 9 years. Top 2 inches of webs rusted out by age 13.3 years. At age 19.2 years top of piles were covered with wood sheathing.

Group
Number

- 81 Location - Miami Beach, Florida, 216 feet S of 44th Street.
Painting - Same as Group 78.
Condition - By age 6 years, paint was being forced off in spots by rust blisters leaving large pits. Paint was completely gone by age 10.3 years, and webs were rusted out at top. New construction prevented repeated measurements of same piles.
- 82- Location - Bakers Haulover, Florida, bulkhead S of inlet, respectively
84 in return at S end, 420 feet and 190 feet S of inlet.
Sand - Median diameter 1.1 to 1.4 mm. about 90% shell.
Condition - At age 9.3 years, flanges were almost completely rusted out. Shortly thereafter, storm waves bent over or broke off webs of many piles leaving interlocks standing 3 feet or 4 feet above remainder of piles. A new bulkhead was built in front of the old one for 300 feet S of the inlet and the intervening space filled with concrete. By age 19.5 years, the top 3 feet to 4 feet of webs in return wall (Group 82) were completely rusted out. The new bulkhead in front of the old one was destroyed by undermining.
- 85 Location - Hollywood Beach, Florida.
Condition - At 2d inspection, age 14.5 years, holes were rusted through piles. Rust about 1/2 inch thick. By 3d inspection, bulkhead had been incorporated in a concrete seawall.
- 86 Location - Palm Beach, Florida, At Palmo Way, about 0.8 mile S of Lake Worth Inlet.
Condition - By age 7 years, a hole had rusted through 1 web. Rust was about 1/2 inch thick over most of exposed area. By age 17.1 years, tops of many piles were rusted away for nearly 1 foot.
- 87 Location - Palm Beach, Florida, about 470 feet S of Angler Avenue and 1 mile S of Lake Worth Inlet.
Condition - Age 5.9 years, rust about 1/2 inch thick and small holes rusted through webs and flanges. At age 11.8 years webs rusted away in top 2 feet of many piles.
- 88 Location - Palm Beach, Florida, N of Monterey Road and about 1 1/4 miles S of Lake Worth Inlet.

Group
Number

- Painting - 1 pile unpainted (88a) 4 piles painted (88b) but not down as far as lowest measured level (elevation 5.5 feet MLW).
- Condition - At age 7 years, paint being forced off by rust blisters, At age 11.2 years no paint remained. At age 17.1 years heavy coating of rust with many small blisters and pits.
- 89 Location - Palm Beach, Florida, foot of Royal Palm Way, about 4.5 miles S of Lake Worth Inlet.
- Steel - Copper bearing.
- Condition - At age 7 years, numerous large blisters and pits; by age 11.2 years several inches of tops of webs were rusted away; by age 17.1 years end pile unprotected by backfill completely rusted out.
- 90 Location - Palm Beach, Florida, 230 feet S of Group 89.
- Steel Copper bearing.
- Painting - 2 piles unpainted (90a) and 3 painted (90b) with hot tar when installed.
- Condition - At age 7 years coating was in good condition, by age 17.1 years almost completely gone, rust about 3/8 inch thick and top 6 inches of web rusted out.
- 91 Location - Palm Beach, Florida, 73 feet N of El Bravo Way and about 5.3 miles S of Lake Worth Inlet.
- Steel - Copper bearing.
- Condition - Little rust at age 7 years; heavy rust by age 11.2 years, rust 1/2 inch thick by age 17.1 years. Marks on piling at age 7 years indicated previous sand elevations to about 12 feet MLW.
- 92-97 incl. Location - Savannah Beach, Tybee Island, Georgia, bulkhead at Fort Screven.
- 92 - 84 feet N of 1st groin from S
- 93 - 250 feet S of 2nd groin
- 94 - Just S of 2d groin
- 95 - Just N of 2d groin

Group
Number

96 - 300 feet S of 3d groin

97 - Just S of 3d groin

Steel - Only 94 b copper bearing.

Condition of Water - Polluted sea water.

Condition -

92 - Tops of flanges of some piles rusted out for several inches by age 9.4 years, webs of some piles rusted out for 2 feet from top by age 15.5 years.

93 - Rust holes in web at top of piles by 9.4 years, web completely rusted out for 12 inches to 18 inches from top in many piles by 15.5 years.

94 - Some webs and flanges completely rusted through by 9.4 years. Webs of all piles completely rusted away for 2 feet from top by 15.5 years. One copper bearing pile in this group (94b).

95 - Flange of 1 pile rusted out down to sand line by 9.4 years. Webs of all piles rusted out for 3 feet from top by 15.5 years.

96 - Holes in flanges by 9.4 years. Webs rusted out for 1 foot from top by 15.5 years.

97 - Flanges rusted out near top and some holes in webs by 9.4 years. Webs rusted out for 1 foot from top by 15.5 years.

98-99 Location - Deal, New Jersey

98 - Near Roseld Avenue

99 - About 1,000 feet S of Group 98.

Exposure - Exposed to ocean wave action.

100 Location - Sea Bright, New Jersey, about 1,000 feet S of Rikers Basin.

Exposure - Exposed to ocean wave action. Riprap in front of bulkhead, also in backfill.

Condition - Piles rusted through at sand line, elevation 4 feet MLW, and flanges from sand line to elevation 8 feet MLW by 16.6 years.

Group
Number

101- Location - Southampton, Long Island, New York
102

102 - W of Halsey Lane

Exposure - Exposed to ocean storm waves.

Condition - Measurement zone covered with sand at 2d inspection.

103 Location - Shoreham, Long Island, New York.

Steel - Copper bearing

Exposure - Exposed to storm waves of Long Island Sound.

Painting - Red lead and aluminum paint when installed.

Beach Material - Gravel.

Part 3 - Groins and Jetties

104- Location - Clearwater Beach, Florida, Carlouel Yacht Club.
106

104-105 - 3d groin from S.

106 - 6th groin from S.

Steel - Copper bearing

Exposure - Gulf storm waves.

Beach Material - Fine sand, 5 to 15 % shell.

Mean Tidal Range - 1.8 feet

Condition - Beach built up by groins, which since serve only to retain accumulated sand.

107- Location - Miami Beach, Florida, groin at foot of 22d Street.
109

Exposure - Ocean waves.

Mean Tidal Range - 2.5 feet.

Marine Life - Group 107, barnacles at elevation 1.8' MLW.
Group 109, barnacles and sabellaria.

Construction - Groin 200 feet long, creosoted timber wales and brace piles.

Beach Material - Medium sand, 68% shell.

Painting - Same as Group 78.

Group
Number

Condition - 107, paint in good condition at 9 years, except scoured off at elevation 0.9 feet M.L.W. Paint in good condition at 13.2 years.

108, paint almost completely gone and rust up to 1/4 inch thick by 13.2 years.

109, some paint remained at 13.2 years, none at 19.1 years.

110- Location - Miami Beach, Florida, groin at foot of 31st Street.

111

Exposure - Ocean waves.

Beach Material - Medium sand, 79% shell.

Mean Tidal Range - 2.5 feet.

Marine Life - Group 111, barnacles and sabellaria at 2d inspection, barnacles only at 3d .

Construction - Length 200 feet.

Painting - Same as Group 78.

Condition - 110, paint gone, heavy rust by 13.2 years, rust up to 1/2 inch thick by 19.1 years. Measurement zone covered by sand after 1st inspection.

111, paint gone, heavy rust by 19.1 years. Holes in flanges by 13.2 years, holes larger and some webs gone by 19.1 years.

112- Location - Miami Beach, Florida, groin 200 feet N of 43d Street.

113

Exposure - Ocean waves.

Beach Material - Coarse sand, 93% shell.

Mean Tidal Range - 2.5 feet

Marine Life - Group 113, barnacles at upper zone at 10.2 years.

Painting - Same as Group 78.

Construction - Length 200 feet.

Condition - Group 112, paint good at 6 years.

Group 113, some paint remained at 10.2 years, none at 16.1 years. Sand covered piles at 16.1 years.

Un- Location - Bakers Haulover, Florida, groins in front of bulkhead S
umber- of inlet.
ed

Group
Number

Exposure - Ocean waves.

Mean Tidal Range - 2.5 feet.

Built - 1926-27

Construction - 35 piles each, shore end 6 feet MLW, outer end 1 foot MLW.

Condition - By 7.6 years flanges and some webs of outer 14 to 18 piles gone for 2 feet or more above sand line. By 9.3 years, an average of 9 piles per groin completely cut off, next 14 piles from outer end were damaged from complete loss of flange and web to some holes in flanges. Landward 12 piles still whole. Metal polished by sand above sand line. By 13.7 years only 5 piles per groin remained; these were badly corroded. Average web thickness of top of 14th pile from bulkhead of 1 groin at 9.3 years, 0.291 inches. Holes beginning to appear in flanges of this pile near sand line. Thickness of top of 21st pile at 9.3 years, 0.363 inches. Holes appearing in web of this pile about 3 feet from top.

114- Location - Palm Beach, Florida, groin at El Playa Way, 1½ miles S
116 of Lake Worth Inlet.

Exposure - Ocean waves.

Beach Material - Coarse sand, 70% shell.

Mean Tidal Range - 2.8 feet.

Marine Life - Algae, barnacles and sabellaria.

Construction - Used piling.

Condition - By 7 years holes extending from sand line upward about 2 feet in 3d to 43d piles from bulkhead. No holes in webs beyond 43d pile. By 11.2 years, all webs gone from sand line upward to about 2 feet. By 17.1 years webs of piles near bulkhead almost completely rusted out.

117 Location - Palm Beach, Florida, groin at Sunset Avenue about 3.6
miles S of Lake Worth Inlet.

Beach Material - Medium sand, 56% shell.

Condition - By 5.4 years piles were completely cut off in a section of groin 40 feet long, holes in flanges 110 feet from shore end. Timber sheathing placed on groin after 1st inspection intact after 8 years.

Group
Number

118- *Location - Palm Beach, Florida, groin 220 feet N of Sunset Avenue.
119

Condition - By 5.3 years holes in flanges starting about 115 feet from bulkhead, increasing in size seaward. At about 145 feet to 185 feet piles completely cut down. Part of groin including Group 119 covered with timber sheathing after 1st inspection. Sheathing in good condition after about 8 years. Rust on unsheathed piling 1/4 inch thick at 15.4 years.

120 Location - Palm Beach, Florida, groin at Royal Palm Way, about 4.5 miles S of Lake Worth Inlet.

Beach Material - medium sand, 60 to 72% shell.

Marine Life - Barnacles and sabellaria.

Construction - In August 1939, forms were placed against sides of piles and filled with concrete between forms and webs for section from 35 feet to 103 feet from bulkhead.

Condition - By 1.7 years at 110 feet from bulkhead flanges were gone from area MLW to +2 feet. By 11.8 years, the top 20 inches of piles beyond the concrete were supported only by their interlocks.

121- Location - Palm Beach, Florida, groin S of Onondaga Avenue, about
123 2,500 feet S of Lake Worth Inlet.

Group 121 - 26 feet from bulkhead.

Group 122 - 67 feet from bulkhead.

Group 123 - 136 feet from bulkhead.

Beach Material - Medium sand, 20 to 59 % shell. Artificial fill placed near groin in 1944.

Construction - Length 151', creosoted timber wales.

Condition - Group 121, covered with sand at each inspection. Rust about 1/8 inch thick.

Group 122, painted with several types of paint when built, most paint gone in 6 months, apparently worn off in bands as sand line shifted up and down.

Group 123, heavy growth of barnacles, sabellaria and plant life.

At 110 feet from bulkhead 10 piles had holes in flanges by 5.3 years. Some holes extended from sand line upward 2 feet.

Group
Number

124- Location - Palm Beach, Florida, groin between Angler Avenue and
126 Esplanade Way, about 3,050 feet S of Lake Worth Inlet.

Group 124 - 23 feet from bulkhead.
Group 125 - 53 feet from bulkhead.
Group 126 - 145 feet from bulkhead.

Beach Material - Medium sand, 41 to 56% shell.

Construction - Length 201 feet. Deep arch piles. Creosoted timber
brace piles and wales.

Condition - Group 124, rust about 1/8 inch thick by 3.3 years.
Group 125, rust about 1/8 inch thick by 9.3 years.
Group 126, growth of barnacles, sabellaria and plant
life. Holes in some webs by 9.3 years. At 85 feet
from bulkhead, holes in flanges of 10 piles by 5.3 years.

127- Location - Palm Beach, Florida, groin at Angler Avenue about 3,700
129 feet S of Lake Worth Inlet.

Group 127 - 22 feet from bulkhead.
Group 128 - 57 feet from bulkhead.
Group 129 - 87 feet from bulkhead.

Beach Material - Medium sand, 39 to 64% shell.

Construction - Length 180 feet. Creosoted timber brace piles and
wales.

Condition - Group 127, badly pitted by 3.4 years. Rust about 1/8 inch
thick by 9.3 years.
Group 128, webs of several piles completely rusted out
in measurement zone by 9.3 years.
Group 129, growth of barnacles, sabellaria and marine
plants. Webs of several piles completely rusted out at
elevation 0.5 feet MLW and holes in all piles seaward of
this group by 9.3 years.
Hole in web of 1 pile 48 feet from bulkhead by 5.3 years.

130- Location - Palm Beach, Florida, groin N of Mocking Bird Terrace, about
132 5,550 feet S of Lake Worth Inlet.

Group 130 - 9 feet from bulkhead.
Group 131 - 68 feet from bulkhead.
Group 132 - 111 feet from bulkhead.

Beach Material - Coarse sand, 42 to 77% shell.

Construction - Length 180 feet. Creosoted timber wales and 2 inches
by 12 inches sheathing from 18 feet to 88 feet from bulk-
head.

Group
Number

Condition - Group 130, piles badly pitted by 3.4 years.

Group 131, sheathing almost completely worn out and hole in 1 pile at elevation 0.7 feet MLW by 9.3 years.

Group 132, growth of barnacles, sabellaria and plant life.

133- Location - Palm Beach, Florida, groin S of Queens Lane, about
135 6,440 feet S of Lake Worth Inlet.

Group 133 - 7 feet from bulkhead

Group 134 - 58 feet from bulkhead

Group 135 - 89 feet from bulkhead

Construction - Length 123 feet. Wales consist of 2 sections of deep arch steel piling. Piles given shop coat of emulsified asphalt. Steel contained 0.35% copper.

Condition - Group 133, little paint remained and piles badly pitted by 5.3 years.

Group 134, paint gone by 3.4 years. Heavy rust and piles badly pitted by 9.3 years.

Group 135, growth of barnacles, sabellaria and plant life.

At 11.1 years numerous holes were found at elevation 1.6 feet MLW. 47 feet from bulkhead to 0.7 feet MLW at 65 feet from bulkhead.

136- Location - Savannah Beach, Tybee Island, Georgia, 2d groin from S
139 end Fort Screven.

Group 136 - 10 feet from bulkhead.

Group 137 - 105 feet from bulkhead.

Group 138 - 147 feet from bulkhead.

Group 139 - 247 feet from bulkhead.

Exposure - Ocean waves.

Beach Material - Fine sand, 2% shell.

Mean Tidal Range - 6.8 feet.

Construction - Length 420 feet.

Condition of Water - Polluted sea water.

Condition - Group 136, holes near top of flanges by 9.4 years. Webs rusted out for about 10 inches from top by 15.5 years.

Group 137, growth of green algae, small barnacles and oysters. Tops of piles deeply pitted, but not rusted through by 15.5 years.

Group 138, growth of green algae, barnacles and oysters. Holes in piles at sand line by 9.4 years. Webs completely gone at sand line by 15.5 years.

Group 139, heavy growth of green algae, barnacles and oysters. Numerous holes at sand line and brace piles had been cut off by 9.4 years.

Group
Number

140- Location - Savannah Beach, Tybee Island, Georgia, 3d groin from S
143 end Fort Screven.

Group 140 - 15 feet from bulkhead
Group 141 - 44 feet from bulkhead
Group 142 - 150 feet from bulkhead
Group 143 - 247 feet from bulkhead

Construction - Length 360 feet.

Condition - Group 140, no holes, but piles deeply pitted and heavily covered with rust.

Group 141, webs rusted out for about 6 inches from top by 15.5 years.

Group 142, heavy growth of green algae, barnacles and oysters. Piles beginning to wear through at sand line by 15.5 years.

Group 143, heavy growth of algae, barnacles, mussels and oysters. Holes in webs and flanges at sand line by 9.4 years. Webs and flanges gone at sand line by 15.5 years.

144- Location - Kure Beach, North Carolina, Ethyl-Dow Chemical Company
145 intake.

Group 144 on outside of N cellular jetty about 70 feet from outer end and midway between high and low water lines.

Group 145 on outside of S cellular jetty, about 30 feet from outer end and just landward of LW line.

Exposure - Ocean waves on one side only, other side covered with sand fill.

Mean Tidal Range - 4.2 feet.

Beach Material - Fine sand, 7% shell.

Marine Life - Green algae and barnacles.

Condition - Group 144, small holes in webs just above sand line by 12.4 years.

Un- Location - Cape May, New Jersey, 5 groins between Patterson Avenue
umber- and 3d Avenue.
ed

Exposure - Ocean waves.

Mean Tidal Range - 4.3 feet.

Group
Number

Beach Material - Gravel and coarse sand.

Construction - Lengths 150 feet, 190 feet, 240 feet, 315 feet, and 325 feet. Built 1929 of copper bearing steel piles. Nominal thickness of web 0.281 inches, of flange 0.250 inches. Top elevations 7.5 feet MLW at shore end, 3.5 feet at seaward end.

Condition - Holes in piles near sand line by 6 years. Holes increased in number and size as observations continued annually through 12th year.

Un- Location - Cape May, New Jersey, 2 groins at Convention Hall and
number- Hunts Pier.
ed

Construction - Length 125 feet. Built 1928 of copper bearing steel piles. Nominal thickness of web 0.281 inches, of flange 0.250 inches.

Condition - Good condition at 7 years. A few holes by 13 years.

Un- Location - Cape May Point New Jersey, 12 groins between Surf and
number- Brainard Avenues.
ed

Exposure - Ocean waves, ice from Delaware Bay.

Beach Material - Gravel and coarse sand.

Mean Tidal Range - 4.6 feet.

Construction - Length 168 feet. Built December 1931 of copper bearing steel piles. Nominal thickness of web 0.281 inches, of flange 0.250 inches. Top elevations 10 feet MLW at shore end, 3 feet at seaward end.

Condition - Holes in piles and parts of outer end destroyed by undermining or ice action by 4 years. By 10 years a section 30 feet long was destroyed in some groins, presumably due to corrosion and abrasion of the steel piling. Others had been protected in this region by precast concrete blocks in 1937 and were intact for a length of about 75 feet. The outer ends of all groins were destroyed, presumably from other causes than corrosion or abrasion.

Un- Location - Cape May Point, New Jersey, 4 groins between Brainard and
number- Alexander Avenues.
ed

Group
Number

Exposure - Ocean waves, ice from Delaware Bay.

Construction - Built June 1929. Length about 132 feet. Nominal thickness of web 0.281 inch, of flange 0.250 inch. Top elevations 10 feet MLLW at shore end, 3.6 feet at seaward end.

Condition - By 6 years many holes in flanges from sand line upward about 3 feet. Some piles lost from outer ends. By 12 years, the groins were destroyed except the landward 50 feet of 2 groins, many holes in remaining piles.

146 Location - Manasquan, New Jersey, groin 200 feet N of Manasquan Inlet.

Exposure - Ocean waves.

Mean Tidal Range - 4 feet.

Beach Material - Medium sand.

Condition - Sand covered location of holes on S side at 1st inspection and whole groin at later inspections.

147 Location - Belmar, New Jersey, jetty on S side Shark River Inlet.

Exposure - Storm waves.

Mean Tidal Range - 4 feet.

Painting - Black paint when installed.

Marine Life - Seaweed on lower portions.

Condition - Paint almost gone by 9 years. Jetty covered with riprap at 3d inspection.

148 Location - Deal, New Jersey, groin at Brighton Avenue.

Steel - Copper bearing.

Exposure - Ocean waves.

Mean Tidal Range - 4.2 feet.

Marine Life - Green algae.

Condition - Web gone by 13.7 years, just above sand line.

Group
Number

- 149 Location - Long Branch, New Jersey, groin at Pavilion Avenue.
Steel - Copper bearing.
Exposure - Ocean waves.
Mean Tidal Range - 4.3 feet.
Beach Material - Medium sand.
Construction - Length 300 feet. Outer end covered with riprap.
By 3d inspection riprap had been extended landward over measurement area.
- 150- Location - Oyster Bay, Long Island, New York, Center Island, groins
151 about 1/4 mile N of Plum Point.
Exposure - Minor waves of Oyster Bay. Strong tidal currents.
Mean Tidal Range - 7.4 feet.
Beach Material - Chiefly gravel, median diameter 2.9 mm.
Construction - Length 16 feet.
- 152- Location - Asharoken Beach, Long Island, New York.
153 Exposure - Waves of Long Island Sound, fetch 20 miles to north,
60 miles to east.
Mean Tidal Range - 7.3 feet.
Beach Material - Coarse sand and gravel, median diameter 1.3 mm.
Painting - Shop coat of black paint. Repainted outer 50 feet
with asphalt paint at age 6 years. Little remained
on top parts by 12 years.
Condition - By 7 years holes appeared at sand line. 2 inch x
12 inch planks placed along sides of piles at sand
line. Sand covered lower holes at 3d inspection.